ENGINEERING CHANGE NOTICE

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Proj. ECN

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Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	Brett C. Simpson, Data Assessment and Interpretation, R2-12, 373-5915	[] Yes [X] No	05/05/97
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14a. Justification (mark one)

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This document was revised per Department of Energy performance agreements and direction from the Washington State Department of Ecology to revise 23 tank characterization reports (letter dated 7/6/95).

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19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

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Safety			Design		
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	N.W. Kirch *NW Kirch*	5-23-97			

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

Tank Characterization Report for Single-Shell Tank 241-C-109

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U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-C-109. This report supports the requirements of the Tri-Party Agreement Milestone M-44-05.

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Tank Characterization Report for Single-Shell Tank 241-C-109

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LIST OF TERMS

1C	first-cycle decontamination waste
1C1	first-cycle decontamination waste (1944 to 1952)
AA	atomic absorption
ANOVA	analysis of variance
ASC	adiabatic scanning calorimetry
Btu/hr	British thermal units per hour
cal/g	calories per gram
CI	confidence interval
Ci	curies
Ci/L	curies per liter
CLP	contract laboratory procedure
cm	centimeters
cP	centipoise
CRQL	contract required quantitation limit (USEPA)
CST	core sampling truck
CWP1	PUREX cladding waste
CW	cladding waste
D	duplicate
df	degrees of freedom
DL	detection limit
DQO	data quality objective
DSC	differential scanning calorimetry
ECN	engineering change notice
ETOX	extractible organic halides
ft	feet
FL	laser fluorimetry
g	grams
gal	gallons
GC	gas chromatography
GEA	gamma energy analysis
g/L	grams per liter
g/mL	grams per milliliter
HASM	Hanford Analytical Services Management
HDW	Hanford defined wastes

LIST OF TERMS (Continued)

HS	hot semiworks
IC	ion chromatography
ICP	inductively coupled plasma-atomic emission spectroscopy
in.	inches
IX	ion exchange
J/g	joules per gram
kg	kilograms
kgal	kilogallons
kJ/g	kilojoules per gram
kL	kiloliters
LANL	Los Alamos National Laboratory
LFL	lower flammability limit
LL	lower limit
m	meters
m/s	meters per second
M	moles per liter
mg/g	milligrams per gram
mL	milliliters
mrad/hr	millirad per hour
MS	mass spectrometry
n/a	not applicable
NA	not available
N/A	not analyzed
n/d	not detected
NM	no measurement
NR	not reported
OGIST	Oregon Graduate Institute of Science and Technology
ORNL	Oak Ridge National Laboratory
Pa	pascals
PHMC	Project Hanford Management Contractor
PNNL	Pacific Northwest National Laboratory
ppmv	parts per million by volume
QC	quality control
REML	restricted maximum likelihood estimation
R/hr	roentgens per hour
RPD	relative percent difference

LIST OF TERMS (Continued)

rpm	revolutions per minute
RSD	relative standard deviation
S	sample
S_τ	shear stress
SMM	supernatant mixing model
SVOA	semi-volatile organic analysis
TBP	tributyl phosphate
TC	total carbon
TCR	tank characterization report
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TLM	tank layer model
TOC	total organic carbon
TOX	total extractible organic halides
TWRS	Tank Waste Remediation System
UL	upper limit
UR	uranium recovery waste
vol%	volume percent
VSS	vapor sampling system
W	watts
WC	weather covered
WSTRS	Waste Status and Transaction Record Summary
wt%	weight percent
°C	degrees Celsius
°F	degrees Fahrenheit
μCi/g	microcuries per gram
μCi/gal	microcuries per gallon
μCi/mL	microcuries per milliliter
μeq/g	microequivalents per gram
μm	micrometers (microns)
μg/g	micrograms per gram
μg/mL	micrograms per milliliter
τ_s	shear strength

1.0 INTRODUCTION

One of the major functions of the Tank Waste Remediation System (TWRS) is to characterize wastes in support of waste management and disposal activities at the Hanford Site. Analytical data from sampling and analysis, along with other available information about a tank, are compiled and maintained in a tank characterization report (TCR). This report and its appendices serve as the TCR for single-shell tank 241-C-109.

The objectives of this report are: 1) to use characterization data in response to technical issues associated with tank 241-C-109 waste; and 2) to provide a standard characterization of this waste in terms of a best-basis inventory estimate. The response to technical issues is summarized in Section 2.0, and the best-basis inventory estimate is presented in Section 3.0. Recommendations regarding safety status and additional sampling needs are provided in Section 4.0. Supporting data and information are contained in the appendices. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996) milestone M-44-03.

1.1 SCOPE

Characterization information presented in this report originated from sample analyses and known historical sources. While only the results of recent sample events will be used to fulfill the requirements of the data quality objectives (DQOs), other information can be used to support (or question) conclusions derived from these results. Historical information, provided in Appendix A, include surveillance information, records pertaining to waste transfers and tank operations, and expected tank contents derived from a process knowledge model.

The recent sampling events listed in Table 1-1, as well as sample data obtained before 1989, are summarized in Appendix B along with the sampling results. The 1992 core sampling efforts were directed by the *Waste Characterization Plan for the Hanford Site Single-Shell Tanks* (Hill et al. 1991), as modified by Hill (1991). The results, of the 1992 sampling event, were originally reported in *Single-Shell Tank Characterization Project and Safety Analysis Project Cores 47, 48, and 49, Validation Report Tank 241-C-109* (Bell 1993). The 1994 vapor sampling event satisfied the data requirements for this tank specified in *Vapor Sampling and Analysis Plan* (Homi 1995). The results of the August 10, 1994, vapor sampling event were reported in *Tank 241-C-109 Headspace Gas and Vapor Characterization Results for Samples Collected in August 1994* (Huckaby and Bratzel 1995).

The statistical analysis and numerical manipulation of data used in issue resolution are reported in Appendix C. Appendix D contains the evaluation to establish the best basis for the inventory estimate. A bibliography that resulted from an in-depth literature search of all known information sources applicable to tank 241-C-109 and its respective waste types is contained in Appendix E. Most of the reports listed in Appendix E may be found in the Tank Characterization and Safety Resource Center.

Table 1-1. Summary of Recent Sampling.

Sample/Date	Phase	Location	Segmentation	% Recovery (Volume Basis)
Core 47 (9/4/92)	Solid/Liquid	Riser 6	quarter segments	70.1
Core 48 (9/6/92)	Solid/Liquid	Riser 7	quarter segments	33.3
Core 49 (9/7/92)	Solid/Liquid	Riser 2	quarter segments	92.3
Vapor sample (8/10/94)	Gas	Tank headspace, riser 4	N/A	N/A

Notes:

N/A = not analyzed

Dates are provided in the mm/dd/yy format.

1.2 TANK BACKGROUND

Tank 241-C-109 is located in the 200 East Area C Tank Farm on the Hanford Site. It is the last tank in a three-tank cascade series. The tank went into service in 1948 with a cascade of first cycle decontamination waste from tank 241-C-108. Supernatant was transferred from the tank in 1952 in preparation to receive tributyl phosphate (TBP) waste, also referred to as uranium recovery (UR) waste. During 1953, TBP waste was transferred into tank 241-C-109. The tank received concentrated In-Farm ferrocyanide-scavenged TBP waste from 1956 to 1957. Supernatant transfers out of the tank occurred periodically from 1956 to 1962. In 1962, tank 241-C-109 received Strontium Semi-works/Hot Semi-works waste. The tank continued to receive hot semi-works waste until 1966. Supernatant was transferred into and out of the tank from 1966 to 1976. Tank 241-C-109 was removed from service in 1976. Intrusion prevention was completed in 1982 and the tank was interim stabilized in 1983 (Agnew et al. 1996)

A description of tank 241-C-109 is summarized in Table 1-2. The tank has an operating capacity of 2,010 kL (530 kgal), and presently contains an estimated 250 kL (66 kgal) of non-complexed waste (Hanlon 1996). The tank was removed from the Ferrocyanide Watch List on June 25, 1996 (Kinzer 1996), and currently is not on other Watch Lists (Public Law 101-510).

Table 1-2. Description of Tank 241-C-109.

TANK DESCRIPTION	
Type	Single-Shell
Constructed	1943 to 1944
In-service	1948
Diameter	22.9 m (75.0 ft)
Operating depth	5.2 m (17 ft)
Capacity	2,010 kL (530 kgal)
Bottom shape	Dish
Ventilation	Passive
TANK STATUS	
Waste classification	Non-complexed
Total waste volume	250 kL (66 kgal)
Supernatant volume	15 kL (4 kgal)
Saltcake volume	0 kL (0 kgal)
Sludge volume	235 kL (62 kgal)
Drainable interstitial liquid volume	0 kL (0 kgal)
Waste surface level (January 1, 1997)	47.63 cm (18.75 in.)
Temperature (September 1975 to January 1997)	13.3 °C (55.9 °F) to 38.9 °C (102 °F)
Integrity	Sound
Watch List	Ferrocyanide[1] (1991 to 1996)
SAMPLING DATES	
Vapor samples	August 1994
Core samples	September 1992
SERVICE STATUS	
Declared inactive	1976
Intrusion prevention	1982
Interim stabilization	1983

Note:

[1]Removed from Ferrocyanide Watch List on June 25, 1996.

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2.0 RESPONSE TO TECHNICAL ISSUES

Two current technical issues have been identified for tank 241-C-109 (Brown et al. 1995). They are:

- Does the waste pose or contribute to any recognized potential safety problems?
- Vapor screening: is there a potential for worker hazards associated with the toxicity of constituents in any fugitive vapor emissions from the tank?

Although the 1992 core sampling event predated current DQOs, those results have been used to address the issues in the safety screening DQO. Vapor screening, was addressed according to the vapor DQO through the 1994 vapor sampling. The ferrocyanide issue substantially impacted the data gathering and analysis protocols for this tank. Therefore, the data relating to issues associated with the closed ferrocyanide issue are presented for completeness. Appendix B presents the analytical results from both the core and vapor sampling events.

2.1 SAFETY SCREENING

The data needed to screen the waste in tank 241-C-109 for potential safety problems is documented in *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). These potential safety problems are exothermic conditions in the waste; flammable gases in the waste and/or tank headspace; and criticality conditions in the waste. Each of these conditions is addressed separately below as applicable to the safety screening DQO. Because the 1992 core sampling and analysis predate the current DQOs, this evaluation is provided for information only.

2.1.1 Exothermic Conditions (Energetics)

The first requirement outlined in the safety screening DQO (Dukelow et al. 1995) is to ensure that there are not sufficient exothermic constituents (organic or ferrocyanide) in tank 241-C-109 to pose a safety hazard. Because of this requirement, the energetics of the tank waste was evaluated. The safety screening DQO required that the waste sample profile be tested for energetics at the half segment, or every 24 cm (9.5 in.), to determine if the energetics exceed the safety threshold limit. The threshold limit for energetics is 480 J/g on a dry weight basis.

Results obtained using differential scanning calorimetry (DSC) indicated that only one sample, core 48 segment 1D, exhibited exotherms. This exotherm was far below the decision limit, with a magnitude of 52 J/g (dry weight basis). Because only one exotherm was observed, no confidence interval calculations were performed. As the results indicate, the probability of a propagating exothermic reaction is quite small, and unlikely, considering the tank waste is approximately 36 percent water. Experiments have shown that bulk runaway reactions are not possible under current tank storage conditions (Fauske 1996).

Based on process data and waste management information, tank 241-C-109 waste was expected to exhibit exothermic properties because of the presence of ferrocyanide in the waste. However, recent studies (Babad et al. 1993; Lilga et al. 1992, 1993, 1994, 1995, and 1996) and analytical data from other ferrocyanide tanks (tanks 241-BY-104 [Benar et al. 1996], 241-BY-106 [Bell et al. 1996], 241-BY-108 [Baldwin 1996], and 241-BY-110 [Simpson et al. 1996] among others) have shown that a large degree of ferrocyanide decomposition occurs due to the combined effects of radiation, temperature, and pH in the harsh environments of the high-level waste tanks.

2.1.2 Flammable Gas

Vapor phase measurements, taken in the tank headspace in August 26, 1992, (Fowler 1992) indicated that the flammability of the headspace gases was below the safety screening threshold of 25 percent of the lower flammability limit (LFL). Data from the 1994 sampling are presented in Appendix B.

2.1.3 Criticality

The safety screening DQO threshold limit is 1 g ^{239}Pu per liter of waste. Assuming that all alpha is from ^{239}Pu and using the overall bulk density of 1.23 g/mL, 1 g/L of ^{239}Pu is equivalent to 50 μCi/g of alpha activity. Total alpha activity was analyzed in accordance with documents requiring analyses of composites instead of half segment or segment level analyses.

Selected samples were analyzed for plutonium and uranium isotopic analyses by mass spectroscopy. Data from these radiological analyses are summarized in Appendix C.

The total alpha activities measured in the liquid and solid core composite samples were well below the 41 μCi/g limit. The single largest result was 0.992 μCi/g. The safety screening DQO requires the upper limit of the one-sided 95 percent confidence interval on the mean be calculated for each sample. Because of consistently low results, no calculations were made for individual samples or for the liquids. A 95 percent confidence interval was calculated on the tank mean, yielding an upper limit of 1.42 μCi/g. Therefore, criticality is not an issue for tank 241-C-109.

2.2 FERROCYANIDE ISSUE

The ferrocyanide safety issue has been resolved for tank 241-C-109; the tank was removed from the Ferrocyanide Watch List on June 25, 1996 (Kinzer 1996). A comparison has been made in Table 2-2 between the 1992 analytical results and the requirements of the ferrocyanide DQO (Meacham et al. 1995). This comparison is for information only, as the requirements are no longer applicable.

2.3 VAPOR SCREENING

The 1994 vapor samples were taken to satisfy the requirements of the *Data Quality Objectives for Generic In-Tank Health and Safety Issue Resolution* (Osborne et al. 1994). The analyses required to meet the vapor DQO requirements were documented in Homi (1995). The vapor DQO addresses the following two problems: 1) potential flammable levels of gases and vapors generated or released in waste storage tank headspaces and, 2) the potential for worker hazards associated with the toxicity of constituents in any fugitive vapor emissions from these tanks. These problems are addressed in this section.

2.3.1 Flammable Gas

This is the same requirement as the safety screening flammability requirement except that the limit in Osborne et al. (1994) is 20 percent of the LFL instead of 25 percent. See Section 2.1.2 for a treatment of the flammability issue. All results from the August 10, 1994, vapor sampling were well below the DQO threshold, and it was determined that no organic or inorganic vapor posed a flammability hazard (Huckaby and Bratzel 1995).

2.3.2 Toxicity

To address the vapor DQO, Homi (1995) required the analysis of ammonia, carbon dioxide, carbon monoxide, hydrogen, methane, nitric oxide, nitrous oxide, nitrogen dioxide, tritium, and water vapor from samples of the tank headspace. Homi (1995) specified a threshold limit for each of the above listed compounds except carbon dioxide, nitrous oxide, tritium, and water vapor.

Aside from water and carbon dioxide, the most abundant waste constituents in the tank 241-C-109 headspace were ammonia (10.1 ppmv), hydrogen (125 ppmv), and nitrous oxide (369 ppmv). Appendix B, Table B2-89 contains the results. The concentrations of these species were below any limits listed in Homi (1995). Note that the concentration of nitrous oxide exceeds the 25 ppmv limit of the current vapor DQO (Osborne and Buckley 1995), however no further sampling is necessary to address vapor sampling issues (Hewitt 1996).

In addition to the inorganic vapors, the analysis of organics were required from both SUMMA[1] canisters and triple sorbent traps. The total organic vapor concentrations were found to be relatively low. The sum of quantitatively measured and estimated triple sorbent trap organic analyte concentrations was 0.934 ppmv (Huckaby and Bratzel 1995).

2.4 OTHER TECHNICAL ISSUES

A factor in assessing tank safety is the heat generation and temperature of the waste. Heat is generated in the tanks from radioactive decay. An estimate of the tank heat load based on radionuclide data from the 1992 sample event is 2,600 W (8,870 Btu/hr), as shown in Table 2-1. Only the radionuclides listed quantities were used in the calculation.

This estimate agrees well with the heat load estimate based on tank headspace temperatures - 2,060 W (7,040 Btu/hr) (Kummerer 1995). The heat load estimate based on the tank process history model was 3,060 W (10,400 Btu/hr) (Agnew et al. 1997). All of these estimates are low, and are well below the 11,700 W (40,000 Btu/hr) limit that separates high- and low-heat load tanks (Bergmann 1986).

Table 2-1. Tank 241-C-109 Projected Heat Load.

Radionuclide	Curies	Watts
^{137}Cs	2.37E+05	1,120
^{90}Sr	2.21E+05	1,480
Total watts		2,600

2.5 SUMMARY

This section summarizes the analytical results for the issues that apply to the tank 241-C-109 waste. Table 2-2 summarizes the results for the safety screening and vapor screening. Some uncertainty exists for total alpha analyses because only core composite data were available for evaluation. All safety screening primary analytes were well below threshold limits. As discussed previously, all the requirements of the vapor DQO (Osborne et al. 1994) were met. All analytical results were well below the ferrocyanide DQO thresholds.

[1]SUMMA is a trademark of Moletrics Inc., Cleveland, Ohio.

Table 2-2. Summary of Safety Screening, Vapor Screening, and Ferrocyanide Evaluation Results.

Issue	Sub-issue	Result
Safety screening	Energetics	An exotherm was observed in only one sample. The sample result from core 48, segment 1D was 52 J/g (dry basis), far below the limit of 480 J/g.
	Flammable gas	All vapor measurements below 25 percent of the LFL.
	Criticality	All analyses were less than 2 μCi/g, well below the threshold of 50 μCi/g total alpha activity (composites).
Vapor screening	Flammability	All vapor measurements were below 20 percent of LFL.
	Toxicity	All analytes were within the toxicity threshold limits of Osborne et al. (1994)[1].
Ferrocyanide[2]	Energetics	Sample result from core 48 was 52 J/g, far below the limit of 480 J/g.
	Moisture	36 wt% (TGA on segments) - well above the 17 wt% limit.
	Nickel	14,100[3] μg/g (composites); above the 8,000 μg/g limit, suggesting nickel ferrocyanide was present once.
	Cyanide	882 μg/g (composites); far below the 39,000 μg/g limit, suggesting a degradation mechanism.

Notes:

[1]If the vapor results were evaluated against the current vapor DQO (Osborne and Buckley 1995), the nitrous oxide concentrations would exceed toxicity limits. Hewitt (1996) documents resolution of other vapor issues.

[2]Tank 241-C-109 has been removed from the Ferrocyanide Watch List (Kinzer 1996), and comparison to the ferrocyanide DQO is included for information only.

[3]Acid digest results for nickel were used due to concerns that the fusion results were contaminated from the nickel crucible used during the fusion procedure.

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3.0 BEST-BASIS INVENTORY ESTIMATE

Information about the chemical and/or physical properties of tank wastes is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, as well as to address regulatory issues. Waste management activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing the wastes into a form that is suitable for long-term storage.

Chemical inventory information generally is derived using two approaches: 1) component inventories are estimated using the results of sample analyses; and 2) component inventories are predicted using a model based on process knowledge and historical information. The most recent model was developed by Los Alamos National Laboratory (LANL) (Agnew et al. 1997). Not surprisingly, information derived from these two different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as standard characterization information for the various waste management activities (Hodgson and LeClair 1996). Appendix D contains the complete narrative regarding the derivation of the inventory estimates presented in Tables 3-1 and 3-2.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-109. (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	24,300	S	
Bi	493	M	
Ca	5,510	S	
Cl	212	S	
TIC as CO_3^{-2}	1,830	S	
Cr	72.2	S	
F^-	202	S	
Fe	5,410	S	
Hg	0.802	M	
K	157	S	
La	12.7	S	
Mn	37	S	
Na	25,400	S	

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-109. (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
Ni	4,060	S	
NO_2^-	11,800	S	
NO_3^-	11,700	S	
OH^-	58,050	E	From charge balance
Pb	971	S	
P as PO_4^{-3}	16,100	S	
Si	1,950	S	
SO_4^{-2}	2,230	S	
Sr	109	S	
TOC	824	S	
U_{TOTAL}	3,730	S	
Zr	0.825	M	Less than value in sample

Note:
[1]S = Sample-based (Appendix B), M = Hanford defined wastes (HDW) model-based, and E = Engineering assessment-based

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-C-109. (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{14}C	0.00569	S	
^{90}Sr	221,000	S	
^{90}Y	221,000	S	

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-C-109. (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{129}I	0.00154	M	
^{137}Cs	237,000	S	
^{137m}Ba	224,000	S	
^{239}Pu	98.6	S	
^{241}Am	44.5	S	

Note:

[1]S = Sample-based, M = HDW model-based, and E = Engineering assessment-based

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4.0 RECOMMENDATIONS

The August 10, 1994, vapor sampling event provided sufficient information to address the needs of the vapor DQO (Osborne et al. 1994). No further vapor sampling efforts are necessary. The results satisfied the governing vapor DQO revision (Rev. 0). However, comparison to the current vapor DQO (Rev. 2) reveals that one analyte would exceed the toxicity limits.

As discussed in Section 2.0, the 1992 core sampling predated the existence of current DQOs. However, analytical results from this event were evaluated against the requirements of the safety screening DQO. All results were well within the safety notification limits. Although the ferrocyanide DQO was no longer applicable, an evaluation was also made between the DQO and the results; again, all requirements were satisfied. The sampling and analysis activities performed for tank 241-C-109 have met requirements for all of the applicable DQO documents. Furthermore, a characterization best-basis inventory was developed for the tank contents.

Table 4-1 summarizes the status of Project Hanford Management Contractor (PHMC) TWRS Program review and acceptance of the sampling and analysis results reported in this TCR. All DQO issues addressed by sampling and analysis are listed in column one of Table 4-1. The second column indicates whether the requirements of the DQO were met by the sampling and analysis activities performed and is answered with a "yes" or a "no." The third column indicates concurrence and acceptance by the program in TWRS that is responsible for the DQO that the sampling and analysis activities performed adequately meet the needs of the DQO. A "yes" or "no" in column three indicates acceptance or disapproval of the sampling and analysis information presented in the TCR.

Table 4-1. Acceptance of Tank 241-C-109 Sampling and Analysis.

Issue	Sampling and Analysis Performed	Program[1] Acceptance
Safety screening DQO	Yes	Yes
Vapor DQO	Yes	Yes

Note:

[1]PHMC TWRS

Table 4-2 summarizes the status of PHMC TWRS Program review and acceptance of the evaluations and other characterization information contained in this report. The evaluations specifically outlined in this report are the evaluation of worker hazards due to contact with tank headspace vapors, and the evaluation to determine whether the tank is safe, conditionally safe, or unsafe. Column one lists the different evaluations performed in this report. Columns two and three are in the same format as Table 4-1. The manner in which concurrence and acceptance are summarized is also the same as that in Table 4-1.

Table 4-2. Acceptance of Evaluation of Characterization Data and Information for Tank 241-C-109.

Issue	Evaluation Performed	Program[1] Acceptance
Waste safety categorization (tank is safe)	Yes	Yes
Tank headspace vapors do not pose a safety concern	Yes	Yes

Note:
[1]PHMC TWRS

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APPENDIX A

HISTORICAL TANK INFORMATION

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APPENDIX A

HISTORICAL TANK INFORMATION

Appendix A describes tank 241-C-109 based on historical information. For this report, historical information includes any information about the fill history, waste types, surveillance, or modeling data about the tank. This information may be useful for supporting or challenging conclusions based on sampling and analysis.

This appendix contains the following information:

- **Section A1:** Current status of the tank, including the current waste levels as well as the isolation status of the tank.
- **Section A2:** Information about tank design.
- **Section A3:** Process knowledge of the tank; that is, the waste transfer history and the estimated contents of the tank based on modeling data.
- **Section A4:** Surveillance data for tank 241-C-109, including surface level readings, temperatures, and a description of the waste surface based on photographs.
- **Section A5:** References for Appendix A.

A1.0 CURRENT TANK STATUS

As of October 31, 1996, tank 241-C-109 contained 250 kL (66 kgal) of non-complexed waste (Hanlon 1996). The waste volumes were estimated using an ENRAF[2] gauge and a manual tape. The volumes of the waste phases found in the tank are shown in Table A1-1. The solids volume was last updated on November 29, 1983.

Tank 241-C-109 was removed from service in 1976. Intrusion prevention was completed in 1982, and the tank was interim stabilized in 1983. Tank 241-C-109 is passively ventilated, categorized as sound, and is not on the Watch List (Public Law 101-510). All monitoring systems were in compliance with documented standards as of October 31, 1996 (Hanlon 1996).

[2]ENRAF is a trademark of ENRAF Corporation, Houston, Texas.

Table A1-1. Estimated Tank Contents.[1]

Waste Form	**Estimated Volume**	
	kL	**kgal**
Total waste	250	66
Supernatant liquid	15	4
Sludge	235	62
Saltcake	0	0
Drainable interstitial liquid	0	0
Drainable liquid remaining	15	4
Pumpable liquid remaining	0	0

Note:

[1]For definitions and calculation methods refer to Appendix C of Hanlon (1996).

A2.0 TANK DESIGN AND BACKGROUND

The C Tank Farm was constructed between 1943 and 1944 in the 200 East Area. The tank farm contains four 200-series and twelve 100-series single-shell tanks. Tank 241-C-109 has a capacity of 2,010 kL (530 kgal), a diameter of 22.9 m (75.0 ft), and an operating depth of 5.18 m (17.0 ft). These tanks were designed to hold concentrated, non-boiling supernatant. The maximum design temperature for liquid storage is 104 °C (220 °F) (Consort et al. 1996).

Tank 241-C-109 entered service during the second quarter of 1948 and is the last tank in a cascade that includes tanks 241-C-107 and 241-C-108. These 100-series single-shell tanks are constructed of 30-cm (1.0-ft) thick reinforced concrete with a 6.35-mm (0.25-in.) mild carbon steel liner, and a 38-cm (1.25-ft) thick domed concrete top. These tanks have a dished bottom with a 1.2-m (4-ft) radius knuckle. The tanks are set on a reinforced concrete foundation. (Consort et al. 1996).

The surface level of tank 241-C-109 is monitored through riser 1 with a manual tape. The tank has two thermocouple trees, one located in riser 3 and the other in riser 8. A saltwell pump is located in riser 13. A list of tank 241-C-109 risers showing their sizes and general use is provided in Table A2-1. Figure A2-1 is a plan view of the riser configuration. A tank cross section showing the approximate waste level, along with a schematic of the tank equipment, is shown in Figure A2-2. Tank 241-C-109 has nine risers. Risers 2, 3, 4, 6, and 7 are tentatively available for sampling (Lipnicki 1996). Risers 2, 3, 6, and 7 are 30 cm (12 in.) in diameter. Riser 4 has a diameter of 10 cm (4 in.).

Tank 241-C-109 has four process inlet nozzles and one cascade overflow inlet.

Table A2-1. Tank 241-C-109 Risers and Nozzles.[1,2,3]

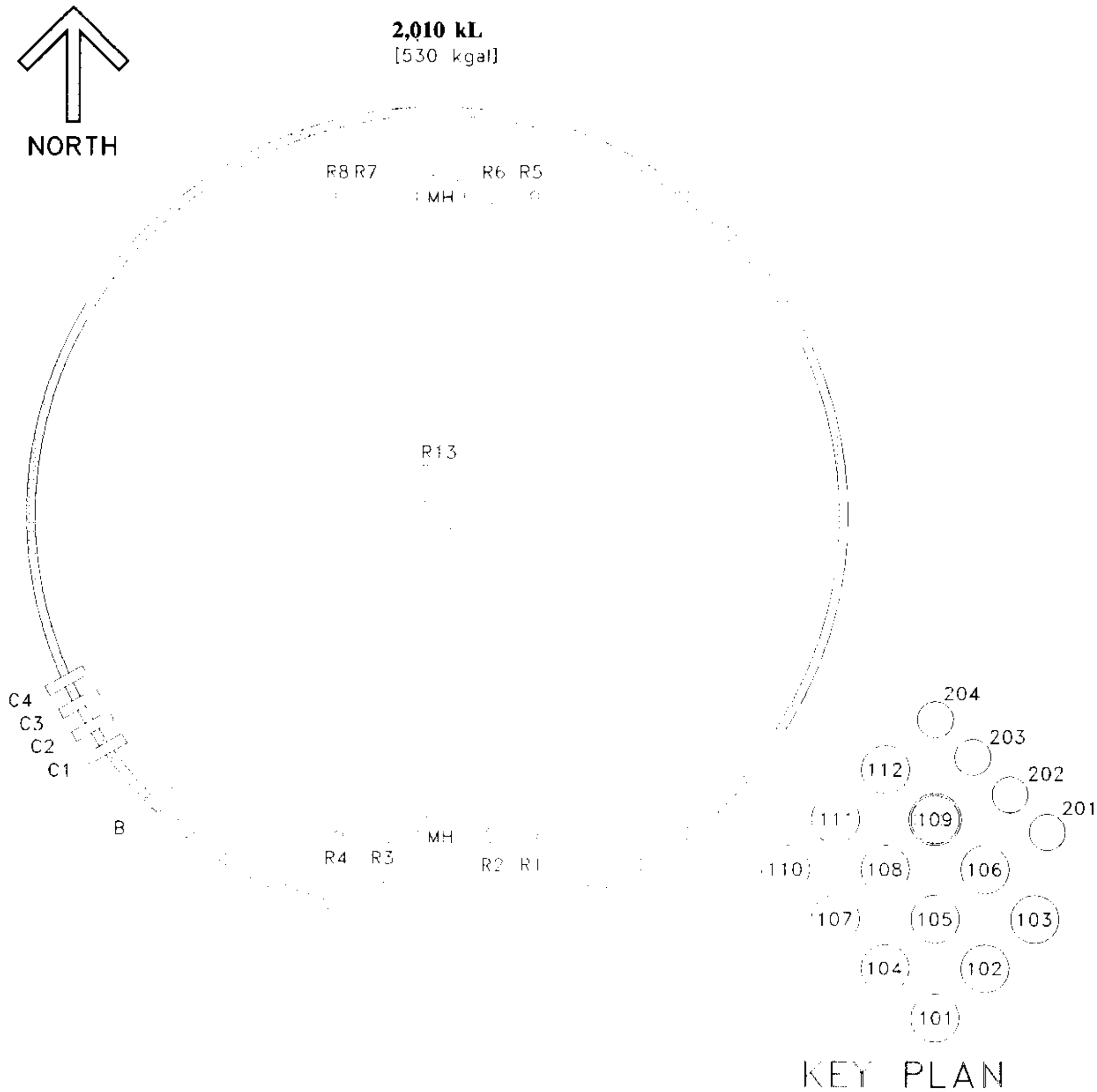
Riser Number	Diameter cm	Diameter in.	Description and Comments
1	10	4	Liquid level reel
2[4]	30	12	Flange (bench mark)
3[4]	30	12	Thermocouple tree
4[4]	10	4	Breather filter [vapor assembly/breather filter offset adapter ECN-618483 01/10/95] [blind flange ECN-618481 06/09/95]
5	10	4	Dry well (flange)
6[4]	30	12	Flange/Spare
7[4]	30	12	B-222 observation port
8	10	4	Thermocouple tree
13	30	12	Saltwell pump, weather covered (WC)
B	8	3	Overflow-inlet nozzle
C1	8	3	Spare, capped
C2	8	3	Spare, capped
C3	8	3	Spare, capped
C4	8	3	Spare, capped

Notes:

ECN = Engineering Change Notice

[1]Alstad (1993)
[2]Tran (1993)
[3]Vitro Engineering Corporation (1986)
[4]Risers tentatively identified for sampling (Lipnicki 1996)

Figure A2-1. Riser Configuration for Tank 241-C-109.



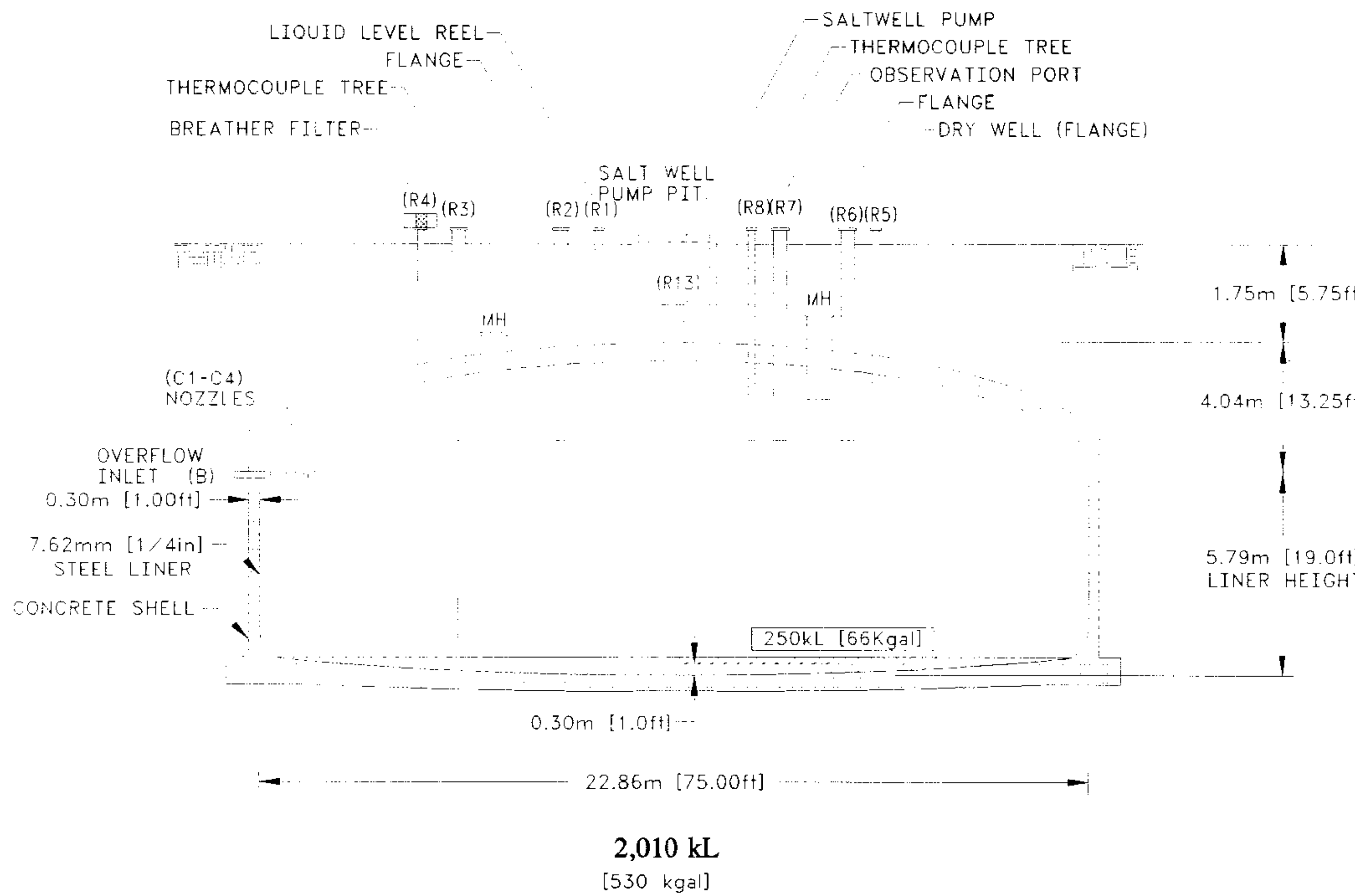


Figure A2-2. Tank 241-C-109 Cross Section and Schematic.

A3.0 PROCESS KNOWLEDGE

The sections below: 1) provide information about the transfer history of tank 241-C-109; 2) describe the process wastes that made up the transfers; 3) give an estimate of the current tank contents based on transfer history; and 4) present results from waste simulant studies.

A3.1 WASTE TRANSFER HISTORY

Tank 241-C-109 was brought into service during the second quarter of 1948 with a cascade from tank 241-C-108 of first-cycle decontamination (1C1) waste from the bismuth phosphate process (Agnew et al. 1997a). The tank was filled by the end of the third quarter of 1948. The waste was transferred to tank 241-B-106 in 1952, leaving an estimated 38 kL (10 kgal) heel. The tank was refilled through the cascade line with unscavenged uranium recovery (UR) waste in 1953.

Beginning in May 1955, unscavenged UR waste already stored in 200 East Area underground tanks at the Hanford Site was routed to the 244-CR vault for scavenging. The 244-CR vault facility contained stainless steel tanks with chemical addition, agitation, and sampling capabilities. The pH was adjusted with HNO_3 and/or NaOH to pH 9.3 $\pm$ 0.7, and $Fe(CN)_6^{4-}$ and Ni^{2+} ion were added (generally to 0.005 *M* each) to precipitate ^{137}Cs.

If laboratory analysis of the feed tank indicated additional ^{90}Sr decontamination was necessary, calcium nitrate was also added (Sloat 1955). There was also an effort to scavenge ^{60}Co with Na_2S. From late 1955 until 1958, tank 241-C-109 was used for settling scavenged ferrocyanide waste. During ferrocyanide-scavenging operations, waste was not cascaded through the tank 241-C-107, 241-C-108, and 241-C-109 series. Tank 241-C-109 received the waste slurry in direct transfers from the process vessel (General Electric 1958). The scavenged waste was settled, sampled, and decanted to a crib. The settling tanks for this In-Farm scavenged waste were tanks 241-C-108, 241-C-109, 241-C-111, and 241-C-112.

The first transfer of scavenged waste for settling was in the fourth quarter of 1955. In-Farm scavenging was completed in December 1957 (General Electric 1958). Agnew et al (1997a) records an additional transfer out of this tank to a crib in the first quarter of 1958. The inventory of solids in tank 241-C-109 at the end of the ferrocyanide-scavenging program, as calculated by Borsheim and Simpson (1991), was 413 kL (109 kgal) with essentially no free supernatant. The scavenging record (General Electric 1958) gives the tank level as 0.89 m (35 in.) (413 kL [109 kgal]). Agnew et al. (1997a) reports a total volume of 424 kL (112 kgal), but lists 341 kL (90 kgal) of that inventory as solids (the reading previous to this was 193 kL [51 kgal]). The waste inventory values believed to be most representative of the solids level (and overall waste inventory) in this timeframe range between 193 and 220 kL (51 and 58 kgal). The wide variation in the waste levels between sources is not reassuring and contributes to significant uncertainty regarding tank inventory calculations.

After the end of scavenging in early 1958, tank 241-C-109 remained in active service. However, the tank had relatively limited activity from 1958 to the end of its service life in 1980. In the third and fourth quarters of 1959, a total of 1,570 kL (415 kgal) of highly alkaline cladding waste and evaporator bottoms were added to the tank, but the reported solids inventory (341 kL [90 kgal]) did not change (Agnew et al. 1996). From the known information, it seems likely there would be an increase of solids and that a transcription error may have occurred. Cladding waste solids would have settled on top of the ferrocyanide sludge already present.

Several small transfers with relatively high concentrations of ^{90}Sr occurred after 1958. In 1962, 519 kL (137 kgal) was transferred to the BY farm. Waste from the strontium semiworks/hot semiworks (HS) was then added at different times to the tank, increasing the total volume listed as 2,020 kL (535 kgal) at the end of 1964 (the reported solids inventory was still 341 kL [90 kgal]). The listed volumes for the fourth quarter report in 1966 are a total volume of 2,090 kL (552 kgal), with a solids volume of 299 kL (79 kgal) (Agnew et al. 1996). While this solids level measurement was the second taken since additional waste was added to the tank following the last scavenging pumpout in 1958, it was the first to use a new electrode to perform the overall volume measurement.

The reported waste volume remained essentially unchanged (between 2,090 and 2,055 kL [552 and 543 kgal]) until a receipt of 72 kL (19 kgal) from tank 241-C-203, and a transfer of 1,500 kL (397 kgal) to tank 241-C-104 in the first quarter of 1970. This transfer left a heel of at least 609 kL (161 kgal). A floating suction pump transfer would not have transferred any solids because the maximum reported solids level was 413 kL (109 kgal) . In addition, there was no mixing equipment in tank 241-C-109 to move the settled ferrocyanide solids into the overlying solids layer. In the second quarter of 1970, an additional transfer of 1,420 kL (375 kgal) from tank 241-C-110 was received. Between 1970 and 1975, the reported solids volume fluctuated widely between 401 and 235 kL (106 and 62 kgal), and the total volume reported decreased from 2,055 kL to 235 kL (543 to 62 kgal) (Agnew et al. 1996).

Some solids may have been transferred, as the reported tank solids volume decreased from 341 kL (90 kgal) to 299 kL (79 kgal). However, the solids transferred would have been those that settled on top of the ferrocyanide solids (that is, cladding waste/evaporator bottoms solids; ferrocyanide waste levels are at approximately 220 kL [58 kgal). The wide fluctuation makes it difficult to derive any firm conclusions regarding the stratification in the tank. Overall sludge volume in the tank may have decreased somewhat between 1958 and 1975 with further settling and compaction from the weight of overlying solids. Although the amount of sludge added since the end of the scavenging campaign is not easily quantifiable, it is likely that the measurements are biased high. Floating suction pumps do not transfer solids readily, and the movement of 76 to 151 kL (20 to 40 kgal) of solids seems unlikely. With the large amounts of concentrated wastes in this tank, there is the possibility that relatively unsaturated supernatants that were transferred into the tank redissolved significant amounts of waste and distributed the material elsewhere in the tank farms.

The final solids measurement before the end of active service (1980) and the present tank surveillance measurement (1983) are identical, 235 kL (62 kgal), and not much above the estimated ferrocyanide waste level (220 kL [58 kgal]). Therefore, it is estimated that an additional 15 kL (4 kgal) of solids is remaining from the transfers into the tank on top of the ferrocyanide during its active service. The major waste transfers to and from tank 241-C-109 are summarized in Table A3-1.

Table A3-1. Summary of Tank 241-C-109 Major Waste Transfers.

Transfer Source	Transfer Destination	Waste Type	Time Period	Estimated Volume[1,2]	
				kL	kgal
241-C-108	---	First cycle decontamination	1948	2,063	545
---	241-B-106	Supernatant	1952	-1,949	-515
241-C-108	---	Uranium recovery	1953	1,828	483
---	241-C-112	In-Tank scavenging waste	1955	-1,752	-463
241-C-101, -102, -106, -107, -108, -110, -111; 241-B-101, -103, -107; 241-BX-111, 241-BY-101, 241-BY-102	---	In-Tank scavenging waste	1956-1957	11,272	2,978
---	Crib B-017, -019, -022, -028, -030, -033, -034, -035	Supernatant	1956-1958	-11,084	-2,928
241-C-105	---	Supernatant	1959	1,571	415
Miscellaneous	---	Flush Water	1959-1960	72	19
Hot semi-works facility	---	Hot semi-works	1962-1965	503	133
241-C-108, -110, -203	---	Supernatant	1966-1970	1,540	407
241-C-104, -103	---	Supernatant	1970-1976	-3,236	-855
---	241-BY-109	Supernatant	1962	-519	-137

Notes:

[1]Unless otherwise noted, data are derived from Agnew et al. (1997a).

[2]Because only major transfers are listed, the sum of these transfers will not equal the current waste volume.

A3.2 HISTORICAL ESTIMATION OF TANK CONTENTS

The historical transfer data used for this estimate are from the following sources:

- Waste Status and Transaction Record Summary (WSTRS) Rev. 4 (Agnew et al. 1997a). The WSTRS is a tank-by-tank quarterly summary spreadsheet of waste transactions.

- Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev 4 (Agnew et al. 1997b). This document contains the Hanford Defined Waste (HDW) list, the Supernatant Mixing Model (SMM), and the Tank Layer Model (TLM).

- Historical Tank Content Estimate for the (Northeast, Northwest, Southeast, Southwest) Quadrant of the Hanford 200 (East or West) Area. This set of four documents compiles and summarizes much of the process history, design, and technical information regarding the underground waste storage tanks in the 200 Areas.

- Hanford Defined Waste list. The HDW list defines the typical sludge, saltcake, and supernatant composition for approximately 50 identified waste types in the HDW model.

- Tank Layer Model. The TLM assigns the sludge and saltcake layer volumes in each tank using waste composition and waste transfer information.

- Supernatant Mixing Model. This is a subroutine within the HDW model that calculates the volume and composition of certain supernatant blends and concentrates.

Using these records, the HDW list and TLM define the sludge and saltcake layers in each tank. The SMM uses information from both the WSTRS and the TLM to describe the supernatants and concentrates in each tank. Together the WSTRS, HDW list, TLM, and SMM determine each tank's inventory estimate. These model predictions are considered estimates that require further evaluation using analytical data.

Based on the Tank Layer Model, the tank consists of 235 kL (62 kgal) of sludge and 15 kL (4 kgal) of supernatant. The sludge layer is further defined (from the top down) as 11 kL (3 kgal) of ferrocyanide waste, 26 kL (7 kgal) of hot semi-works waste, 159 kL (42 kgal) of ferrocyanide waste, and 38 kL (10 kgal) of $BiPO_4$ first cycle decontamination waste and/or uranium recovery waste.

First cycle waste would be comparatively high (greater than 1 wt%) in bismuth, phosphate, and aluminum because aluminum decladding waste was combined with it. The UR waste solids were comparatively high in uranium and iron, and low (less than 0.1 wt%) in bismuth and aluminum. Neither of these waste types had any significant fuel content or heat-generating radionuclides (^{137}Cs or ^{90}Sr), that could contribute to the exothermic potential posed by ferrocyanide wastes.

The In-Farm precipitate comprises 20 to 25 percent of the total ferrocyanide material in the Hanford Site tank farms. This material is expected to possess a much higher ferrocyanide concentration content than the more prevalent (70 percent of the total ferrocyanide material) U Plant material. Analytes that differentiate ferrocyanide waste from other wastes are elevated levels of nickel, calcium, and ^{137}Cs. Over time, additional gravity settling may have compressed the waste layers, increasing the concentration of some of these analytes. However, the interactive effects of radiation elevated temperature and high pH conditions from later waste additions on the waste matrix has degraded the ferrocyanide. Laboratory results confirming that hypothesis have been documented (Lilga et al. 1992, 1993, 1994, 1995, and 1996; Grigsby et al. 1996, and Babad et al. 1993).

The last of the major waste types was aluminum cladding waste. These materials would be high in aluminum and silica, with a very high pH (>1.0 *M* NaOH; pH $\geq$ 14). The solids volume contribution to the tank is unknown because the majority of the solids were deposited in an initial tank and then transferred to tank 241-C-109. The high pH of this waste is considered a significant factor affecting the state of the waste matrix.

Other wastes had discernable impacts on the bulk characteristics of the tank contents. The strontium semiworks waste had a small volume of waste added, but has a very high ^{90}Sr content because it included strontium recovery and purification waste losses. The B Plant ion-exchange waste was primarily liquid and was not expected to contribute significantly to the solids in the tank.

Figure A3-1 shows a graphical representation of the estimated waste types and volumes. Table A3-2 presents the historical tank inventory estimate of the expected waste constituents and concentrations for tank 241-C-109.

Figure A3-1. Tank Layer Model for Tank 241-C-109.

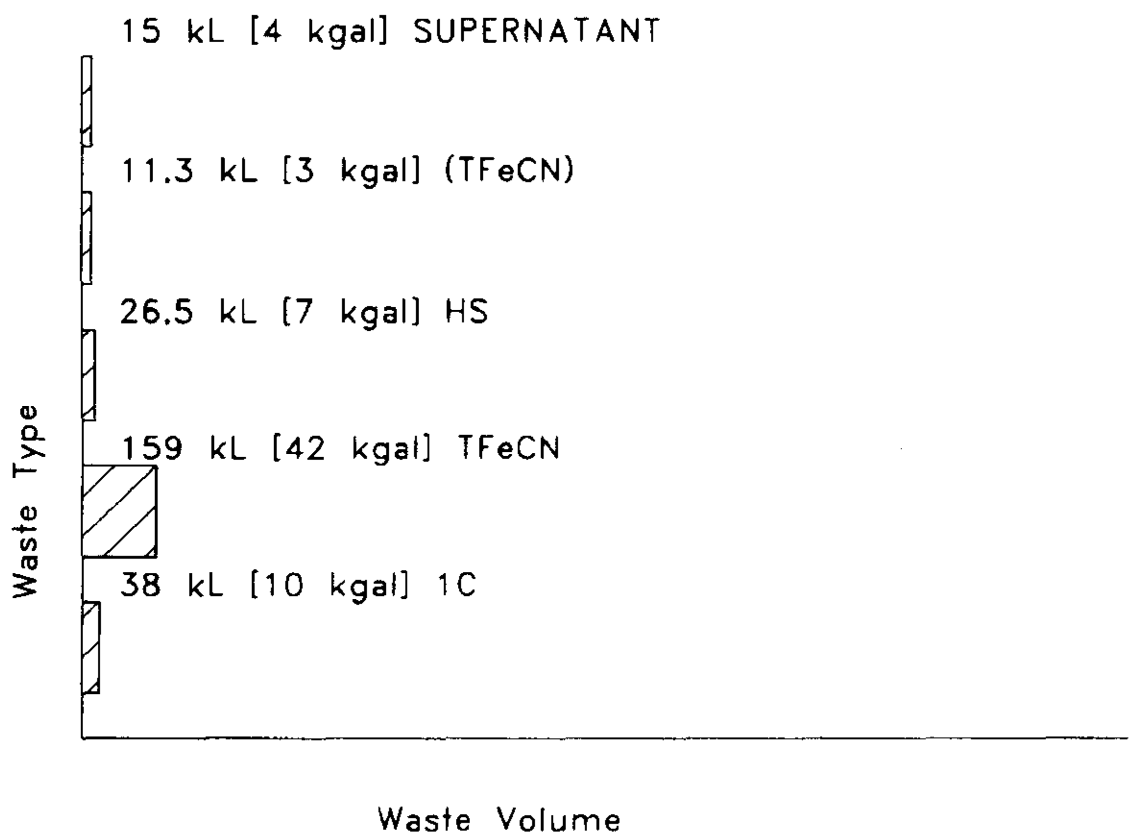


Table A3-2. Tank 241-C-109 Historical Tank Inventory Estimate.[1,2] (4 sheets)

Total Inventory Estimate					
Physical Properties		**μg/g**	**kg**	**-95 Confidence Interval**	**+95 Confidence Interval**
Total waste (kg) [kgal]	3.35E+05 [66.0]	---	---	---	---
Heat load (W)	3,060	---	---	2,940	3,160
Heat load (Btu/hr)	10,500	---	---	10,000	10,800
Bulk density[3] (g/mL)	1.34	---	---	1.33	1.54
Water (wt%)[3]	66.0	---	---	47.7	66.9
TOC (wt% C) (wet)[3]	1.47	---	---	1.28	1.50
Chemical Constituents	***M***	**μg/g**	**kg**	**-95 Confidence Interval (*M*)**	**+95 Confidence Interval (*M*)**
Na^+	3.32	56,900	19,100	3.03	7.37
Al^{3+}	0.0907	1,820	611	0.0907	0.0907
Fe^{3+} (total Fe)	0.898	37,400	12,500	0.890	0.906
Cr^{3+}	0.00143	55.7	18.6	0.00128	0.00159
Bi^{3+}	0.00945	1,470	493	0.00750	0.0105
La^{3+}	0	0	0	0	0
Hg^{2+}	1.60E-05	2.40	0.802	1.11E-05	1.86E-05
Zr (as $ZrO(OH)_2$)	3.62E-05	2.46	0.825	2.88E-05	4.39E-05
Pb^{2+}	0.0161	2,480	832	0.00971	0.0224
Ni^{2+}	0.464	20,300	6,810	0.460	0.468
Sr^{2+}	0	0	0	0	0
Mn^{4+}	0	0	0	0	0
Ca^{2+}	0.554	16,600	5,540	0.385	0.722
K^+	0.0160	466	156	0.0139	0.0174

Table A3-2. Tank 241-C-109 Historical Tank Inventory Estimate.[1,2] (4 sheets)

Total Inventory Estimate					
Chemical Constituents	***M***	**μg/g**	**kg**	**-95 Confidence Interval (*M*)**	**+95 Confidence Interval (*M*)**
OH^-	2.92	37,000	12,400	2.89	2.94
NO_3^-	0.166	7,680	2,570	0.140	4.78
NO_2^-	1.67	57,400	19,200	1.20	1.72
CO_3^{2-}	0.554	24,800	8,310	0.386	0.723
PO_4^{3-}	0.254	18,000	6,030	0.182	0.393
SO_4^{2-}	0.0236	1,690	566	0.0208	0.0253
Si (as SiO_3^{2-})	0.0339	710	238	0.0174	0.0499
F^-	0.0210	298	99.9	0.0167	0.0490
Cl^-	0.0421	1,110	372	0.0328	0.0431
$C_6H_5O_7^{3-}$	0.00350	493	165	0.00284	0.00415
$EDTA^{4-}$	0.00699	1,500	503	0.00568	0.00830
$HEDTA^{3-}$	0	0	0	0	0
$Glycolate^-$	0	0	0	0	0
$Acetate^-$	0.0446	1,960	657	0.0362	0.0529
$Oxalate^{2-}$	0	0	0	0	0
DBP	0	0	0	0	0
Butanol	0	0	0	0	0
NH_3	0.198	2,510	841	0.181	0.456
$Fe(CN)_6^{4-}$	0.243	49,200	16,500	0.243	0.243
Radiological Constituents	**Ci/L**	**μCi/g**	**Ci**	**-95 Confidence Interval (Ci/L)**	**+95 Confidence Interval (Ci/L)**
H-3	2.43E-06	0.00182	0.608	1.73E-06	2.51E-06
C-14	4.69E-07	3.50E-04	0.117	3.50E-07	4.83E-07
Ni-59	1.97E-05	0.0147	4.93	1.75E-05	2.17E-05
Ni-63	0.00187	1.4	468	0.00165	0.00206
Co-60	1.32E-07	9.86E-05	0.0330	1.05E-07	3.27E-07
Se-79	2.31E-07	1.72E-04	0.0576	1.49E-07	1.95E-05
Sr-90	1.40	1,040	3.49E+05	1.33	1.46
Y-90	1.40	1,040	3.50E+05	1.33	1.46

Table A3-2. Tank 241-C-109 Historical Tank Inventory Estimate.[1,2] (4 sheets)

Total Inventory Estimate					
Radiological Constituents	**Ci/L**	**μCi/g**	**Ci**	**-95 Confidence Interval (Ci/L)**	**+95 Confidence Interval (Ci/L)**
Zr-93	1.05E-06	7.83E-04	0.262	6.87E-07	8.91E-05
Nb-93m	8.85E-07	6.60E-04	0.221	5.64E-07	7.13E-05
Tc-99	3.26E-06	0.00243	0.814	2.43E-06	3.35E-06
Ru-106	2.64E-10	1.97E-07	6.60E-05	2.04E-10	2.01E-08
Cd-113m	2.64E-06	0.00197	0.659	1.92E-06	2.93E-04
Sb-125	2.19E-07	1.63E-04	0.0547	1.94E-07	2.43E-07
Sn-126	3.60E-07	2.68E-04	0.0898	2.28E-07	3.05E-05
I-129	6.15E-09	4.59E-06	0.00154	4.59E-09	6.33E-09
Cs-134	4.93E-08	3.68E-05	0.0123	4.93E-08	4.93E-08
Cs-137	0.603	450	1.51E+05	0.603	0.604
Ba-137m	0.571	426	1.43E+05	0.571	0.571
Sm-151	8.63E-04	0.644	216	5.59E-04	0.0717
Eu-152	1.01E-05	0.00754	2.52	1.01E-05	1.01E-05
Eu-154	7.06E-06	0.00527	1.76	2.44E-06	3.09E-04
Eu-155	6.69E-04	0.499	167	6.68E-04	6.70E-04
Ra-226	1.06E-09	7.88E-07	2.64E-04	3.47E-10	2.10E-09
Ra-228	9.58E-15	7.14E-12	2.39E-09	9.56E-15	9.59E-15
Ac-227	5.17E-09	3.86E-06	0.00129	1.06E-09	9.90E-09
Pa-231	4.19E-10	3.13E-07	1.05E-04	3.25E-10	1.94E-08
Th-229	1.78E-12	1.33E-09	4.45E-07	1.78E-12	1.78E-12
Th-232	1.33E-16	9.89E-14	3.31E-11	9.87E-17	1.36E-16
U-232	3.00E-11	2.24E-08	7.50E-06	2.82E-11	3.10E-11
U-233	1.78E-12	1.33E-09	4.45E-07	1.67E-12	1.84E12
U-234	2.49E-06	0.00186	0.622	2.34E-06	2.57E-06
U-235	1.12E-07	8.35E-05	0.0280	1.05E-07	1.16E-07
U-236	1.61E-08	1.20E-05	0.00401	1.51E-08	1.66E-08
U-238	2.19E-05	0.0164	5.48	1.65E-05	2.26E-05
Np-237	1.94E-08	1.45E-05	0.00485	1.43E-08	2.00E-08

Table A3-2. Tank 241-C-109 Historical Tank Inventory Estimate.[1,2] (4 sheets)

Total Inventory Estimate					
Radiological Constituents	Ci/L	μCi/g	Ci	-95 Confidence Interval (Ci/L)	+95 Confidence Interval (Ci/L)
Pu-238	9.43E-06	0.00703	2.36	7.14E-06	1.17E-05
Pu-239	4.03E-04	0.301	101	3.02E-04	5.64E-04
Pu-240	6.57E-05	0.0490	16.4	4.94E-05	8.20E-05
Pu-241	6.80E-04	0.507	170	5.15E-04	8.43E-04
Pu-242	3.34E-09	2.49E-06	8.35E-04	2.55E-09	4.12E-09
Am-241	1.35E-04	0.101	33.7	3.19E-06	4.78E-04
Am-243	3.22E-09	2.40E-06	8.05E-04	7.69E-11	1.02E-08
Cm-242	2.34E-07	1.75E-04	5.85E-02	2.34E-07	2.34E-07
Cm-243	1.22E-08	9.11E-06	0.00305	1.22E-08	1.22E-08
Cm-244	5.88E-09	4.39E-06	0.00147	4.69E-09	4.49E-07
Pu	0.00678 (g/L)	---	1.69 (kg)	0.00509 (g/L)	0.00942 (g/L)
U	0.0317 (*M*)	5,630 (μg/g)	1,890 (kg)	0.0298 (*M*)	0.0328 (*M*)

Notes:

[1]Agnew et al. (1997). These estimates have not been validated and should be used with caution.
[2]Unknowns in tank solids inventory are assigned by Tank Layer Model.
[3]Volume average for density, mass average water wt%, and TOC wt% Carbon.

A3.3 ANALYTICAL RESULTS FROM SIMULANT STUDIES

Physical and chemical measurements performed on simulants of ferrocyanide tank waste provide additional information and perspective regarding the condition and properties of the waste in tank 241-C-109.

A3.3.1 Simulant Formulation: In-Farm 2 Flowsheet Material

The In-Farm 2 flowsheet material is considered an energetically conservative but reasonably close physical and chemical analogue of some of the ferrocyanide precipitate in tank 241-C-109. Scavenging of evaporated cladding and first-cycle wastes is expected to produce noticeable differences from the uranium-recovered, scavenged tributyl phosphate waste. The In-Farm 2 flowsheet materials were prepared according to the instructions in Jeppson and Wong (1993).

The simulant product sludge was the precipitate produced when performing the following steps, which mimicked the actual In-Farm 2 process. The feed solution was heated to 40 °C (104 °F) and the pH adjusted to 9.1 $\pm$ 0.5. The sodium ferrocyanide was then added to the solution, followed by nickel sulfate. The simulant solution was agitated for 1 hour, then struck with calcium nitrate. After the addition of calcium nitrate, the solution was agitated for another hour and allowed to settle. The settling was done for eight days and the supernatant was decanted. The remaining sludge was centrifuged at 2,100 gravities for 14 hours and 1,820 gravities for 7 days in an attempt to simulate 3.6 and 30 gravity-years of settling, respectively. Selected physical properties for the two settled sludges are presented in Jeppson and Wong (1993).

A3.3.2 Energetics Behavior of Ferrocyanide Sludge Simulant

Available chemical process information indicates that three significantly different types of ferrocyanide waste existed at the Hanford Site (Sloat 1954; Schmidt and Stedwell 1954). Nonradioactive waste simulants have been developed and tested using this information. In-Farm ferrocyanide waste, accounting for 20 to 25 percent of the total ferrocyanide waste, was formed from treatment of waste that was already stored in the tanks. The waste in tank 241-C-109 was produced using the In-Farm process. Most of this waste had less inert solid material in the waste stream; therefore, it is believed to have been more concentrated in ferrocyanide than other scavenged wastes. In-Farm simulants exhibit propagating exothermic activity when examined by differential and adiabatic scanning calorimetry (DSC and ASC) (Cady 1992; Fauske 1992).

Estimates of tank waste reactivity were based on thermodynamic estimates (Colby and Crippen 1991). Several chemical reaction pathways were evaluated and heats of reaction were determined for each possible reaction from the published heats of formation of the reactants and the products. For the purpose of developing these estimates, the condition of the reactants are dry solid reagents at standard temperature and pressure in a stoichiometric ratio. The theoretical heats of reaction ranged in value from $\Delta H = -9.6$ kJ/g to $\Delta H = +19.7$ kJ/g of $Na_2NiFe(CN)_6$, and are listed below with their corresponding chemical reactions.

(1) $$Na_2NiFe(CN)_6 + 54NaNO_3 + 22H_2O \rightarrow 6Na_2CO_3 + FeO + NiO + 60NO_2 + 44NaOH$$
$$\Delta H = +19.7 \text{ kJ/g of } Na_2NiFe(CN)_6$$

(2) $$Na_2NiFe(CN)_6 + 14NaNO_3 + 2H_2O \rightarrow 6Na_2CO_3 + FeO + NiO + 20NO + 4NaOH$$
$$\Delta H = -0.7 \text{ kJ/g of } Na_2NiFe(CN)_6$$

(3) $Na_2NiFe(CN)_6 + 9NaNO_3 \rightarrow 5.5Na_2CO_3 + FeO + NiO + 7.5N_2O + 0.5CO_2$
$\Delta H = -6.8$ kJ/g of $Na_2NiFe(CN)_6$

(4) $Na_2NiFe(CN)_6 + 10NaNO_3 \rightarrow 6Na_2CO_3 + FeO + NiO + 6N_2O + 4NO$
$\Delta H = -5.7$ kJ/g of $Na_2NiFe(CN)_6$

(5) $Na_2NiFe(CN)_6 + 9NaNO_3 \rightarrow 4Na_2CO_3 + FeO + NiO + 6N_2 + 2CO_2$
$\Delta H = -9.6$ kJ/g of $Na_2NiFe(CN)_6$

At temperatures below 1,700 °C (3,100 °F), the carbonate product is thermodynamically favorable and should predominate (Scheele et al. 1991). Note that considerably lower energy releases are obtained if the reaction is incomplete or if NO or NO_2 is formed rather than N_2 or N_2O. Further detail regarding the thermodynamic energy estimates of these mixtures is presented in Colby and Crippen (1991).

During the DSC examinations, the simulant samples exhibited large endotherms between room temperature and 150 °C (300 °F) (Jeppson and Wong 1993). Results from thermogravimetric analyses being run at the same time showed a large loss of mass (that is, evaporation of water) in this same temperature range; thus, reactions were only able to occur in dry or nearly dry sample material (Cady 1992). Average ferrocyanide content of the In-Farm 2 waste simulants is approximately 10.1 wet wt% (20.6 wt% dry). Fauske (1992) presents the ΔH found for some simulant materials.

A4.0 SURVEILLANCE DATA

Tank 241-C-109 surveillance data consist of surface level measurements (liquid and solid), temperature monitoring inside the tank (waste and vapor space), and leak detection well monitoring for radioactive liquids outside the tank. Surveillance data provide the basis for determining tank integrity.

A4.1 SURFACE LEVEL READINGS

Waste surface level monitoring in tank 241-C-109 is performed with a manual tape at riser 1. The waste surface level on January 1, 1997 was 47.63 cm (18.75 in.), which is approximately 243 kL (64.1 kgal). A graphical representation of the volume measurements is presented as a level history graph in Figure A4-1.

A4.2 INTERNAL TANK TEMPERATURES

Internal tank temperature data for tank 241-C-109 were recorded by thermocouple probes located on two different thermocouple trees. Temperature data were evaluated from the Surveillance Analysis Computer System recorded from 1975 to 1997. However, not all thermocouples have data covering the entire period (Consort et al. 1996). The average temperature during this period was 24.9 °C (76 °F) with a maximum of 38.9 °C (102 °F) (recorded from the thermocouple tree in riser 8) and a minimum of 13.3 °C (55.9 °F) (recorded from the thermocouple tree in riser 8). A graph of the weekly high temperature data is shown in Figure A4-2.

The thermocouple tree in riser 3 has ten thermocouples with thermocouple 1 located 46.9 cm (1.54 ft) above the tank bottom. Thermocouples 2 to 5 are spaced 15 cm (0.50 ft) apart and thermocouples 6 to 10 are approximately 61 cm (2 ft) apart with thermocouple 10 at an elevation of (4.69 m) 15.4 ft (Tran 1993). All thermocouples, with the exception of 6, 7, 8, and 9, have data available since July 1995 (Consort et al. 1996). The minimum temperature on January 13, 1997 was 22.7 °C (72.9 °F) on thermocouple 4; the maximum temperature on the same date was 23.8 °C (74.8 °F) on thermocouple 1.

The thermocouple tree in riser 8 has eleven thermocouples with thermocouple 1 located 42.7 cm (1.4 ft) above the tank bottom. Thermocouples 2 to 9 are spaced 61 cm (2.0 ft) apart and thermocouples 10 and 11 are approximately 122 cm (4 ft) apart with thermocouple 11 at an elevation of (7.74 m) 25.4 ft (Tran 1993). Data is available after March 1994 for thermocouples 1, 2, 8, and 11 are currently functioning (Consort et al. 1996). The minimum temperature on January 13, 1997 was 19.9 °C (67.8 °F) on thermocouple 11; the maximum temperature on the same date was 23.8 °C (74.8 °F) on thermocouple 1.

A4.3 TANK 241-C-109 PHOTOGRAPHS

The clearest and most recent set of interior tank photographs were taken on December 9, 1974. The waste appears to be covered with pools of supernatant. Other interior tank photographs are available, but only the photographs showing the waste surface were used to create a montage. The montage has labels identifying some of the monitoring equipment, piping, and risers in the tank (Consort et al. 1996). The photographs may not represent current tank contents due to stabilization efforts.

Figure A4-1. Tank 241-C-109 Level History.

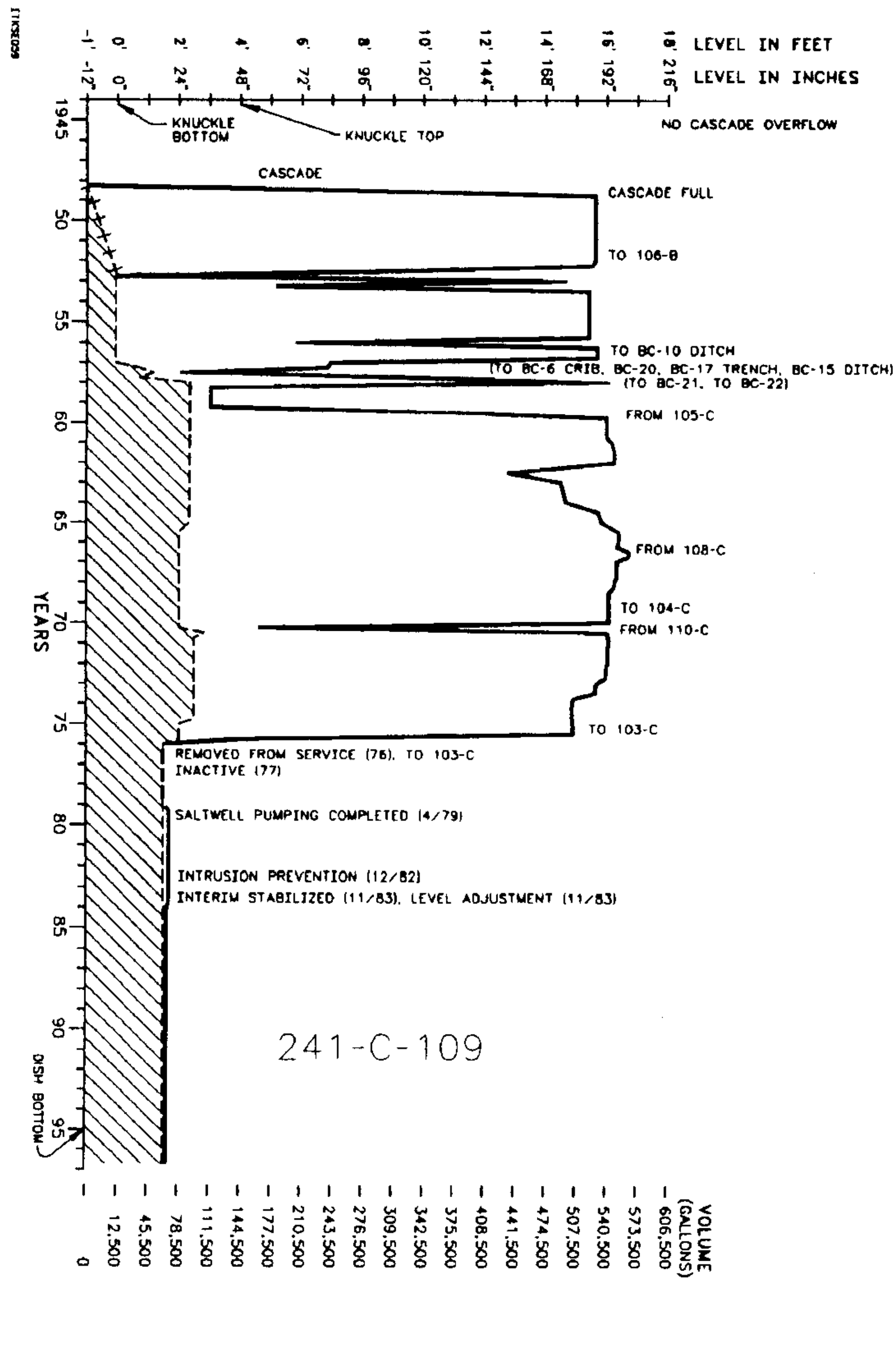
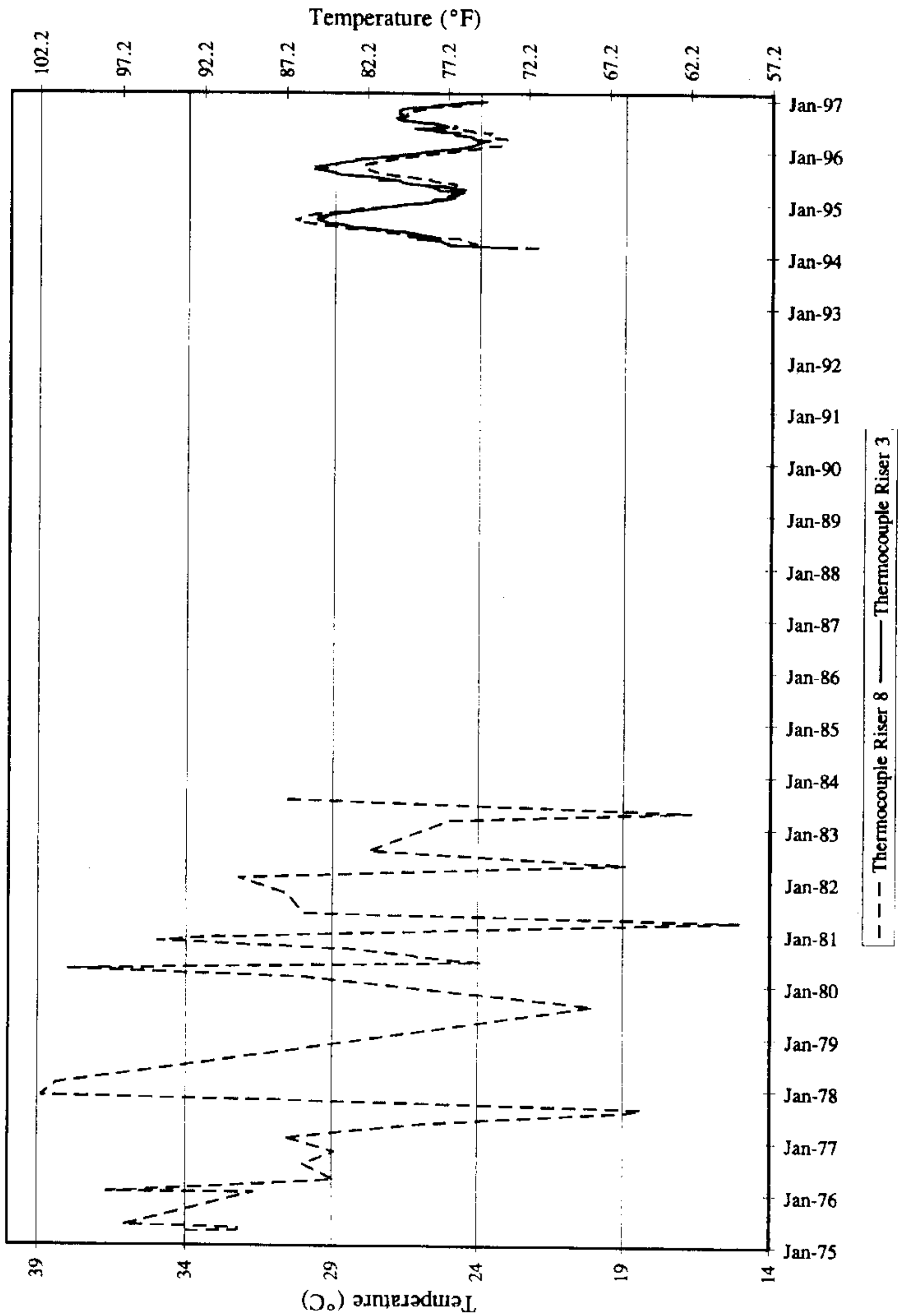


Figure A4-2. Tank 241-C-109 Weekly High Temperature Plot.



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APPENDIX B

SAMPLING OF TANK 241-C-109

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APPENDIX B

SAMPLING OF TANK 241-C-109

Appendix B provides sampling and analysis information for each known sampling event for tank 241-C-109 and an assessment of the core sample results.

- **Section B1**: Tank Sampling Overview
- **Section B2**: Sampling Events
- **Section B3**: Assessment of Characterization Results
- **Section B4**: References for Appendix B.

Future sampling of tank 241-C-109 will be appended to the above list.

B1.0 TANK SAMPLING OVERVIEW

Appendix B describes all known sampling events for tank 241-C-109, and presents the analytical results for each event. The sampling events listed include: the 1992 core sampling event, the 1995 vapor sampling event; and the 1975, 1980, and 1990 historical events.

Core samples were taken in September 1992; although not taken according to a DQO, the analytical results have been used for comparison with the requirements of the safety screening (Dukelow et al. 1995) and ferrocyanide (Meacham et al. 1995) DQOs. The sampling and analysis were performed in accordance with the single-shell waste characterization plan (Hill et al. 1991, as modified by Hill [1991]). Results from the sampling event were reported in Bell (1993).

Tank headspace samples were taken in August 1994 to satisfy the requirements of the *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issue Resolution* (Osborne et al. 1994). The sampling and analysis were performed in accordance with *Vapor Sampling and Analysis Plan* (Homi 1995). The results were reported in *Tank 241-C-109 Headspace Gas and Vapor Characterization Results for Samples Collected in August 1994* (Huckaby and Bratzel 1995).

Safety screening analyses include: total alpha to determine criticality, DSC to ascertain the fuel energy value, thermogravimetric analysis (TGA) to obtain the total moisture content, and bulk density. In addition, combustible gas meter readings in the tank headspace were performed to measure flammability. Sampling and analytical requirements from the safety screening, vapor, and ferrocyanide DQOs are summarized in Table B1-1.

Table B1-1. Integrated Data Quality Objective Requirements for Tank 241-C-109.[1,2,3]

Sampling Event	Applicable DQOs	Sampling Requirements	Analytical Requirements
1992 core samples	Safety screening[4]	Core samples from a minimum of two risers separated radially to the maximum extent possible.	• Energetics • Moisture content • Total alpha • Bulk density
	Ferrocyanide[4,5]		• Energetics • Moisture content • Cyanide • Nickel
1994 vapor samples	Vapor	Measurement in a minimum of one location within tank vapor space.	• Gases (ammonia, CO_2, CO, NO, NO_2, N_2O, TOC, tributyl phosphate, n-dodecane, and n-tridecane) • Vapor flammability

Notes:

[1]Dukelow et al. (1995)
[2]Meacham et al. (1995)
[3]Osborne et al. (1994)
[4]DQO did not exist at the time of sampling.
[5]Removed from Ferrocyanide Watch List and no longer applicable.

Historical sampling events were reported for tank 241-C-109 in 1975, 1980, and 1990. No information was available regarding sample handling and analysis for the samples, therefore, only analytical results and references are reported. Section B2.3 presents the results from these sampling events.

B2.0 SAMPLING EVENTS

B2.1 SEPTEMBER 1992 CORE SAMPLING EVENT

This section describes the core sampling and analysis event for tank 241-C-109 which occurred during September 1992.

B2.1.1 Description of 1992 Core Sampling Event

Tank 241-C-109 was push-mode core sampled through three risers from September 4, 1992 to September 7, 1992. One segment was expected from each core sample. Core 47 was obtained from riser 6. Core 48 was obtained from riser 7. Core 49 was obtained from riser 2. The core samples from tank 241-C-109 were obtained using a specially designed core sampling truck (CST). The sampling equipment is mounted on a rotating platform on the CST. Access to the interior of the tank is provided by various tank risers. These risers are pipes of various diameters leading into the tank dome space. A review of the tank farm operating records and a field inspection of the tank risers determine which risers can be used in the sampling operation. A riser is opened and the CST is positioned over the riser. The sampler is lowered into the tank through the drill string and pushed into the waste.

The sampler is constructed of stainless steel and is 48 cm (19 in.) long, with a 2.2-cm (7/8-in.) inside diameter, and has a volume of 187 mL (0.05 gal). Tank Farm Operations has determined that sampling events of one or two segments do not require hydrostatic head balance fluid. Therefore, none was used in this operation, which eliminated any potential problems with sample contamination. When a segment is captured by the sampler, it is sealed within a stainless steel liner, and the liner is placed within a shipping cask. The shipping casks are approximately 122 cm (48 in.) tall, 13 cm (5 in.) in diameter, and have 2.5 cm (1 in.) of lead shielding. This degree of shielding and containment protects workers from excessive radiological exposure and prevents any liquids from the sample (or the sample itself) from being lost. Refer to the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994) for more information on sampling.

B2.1.2 1992 Core Sample Handling

The casks were transported to the 325 Analytical Chemistry Laboratory for characterization analysis. This laboratory is operated by Pacific Northwest National Laboratory (PNNL) in the 300 Area of the Hanford Site.

The location of the risers, the dished bottom of the tank, and safety margins in the sampling protocol preclude obtaining samples from the entire waste depth in the tank. Thus, the maximum recovery for the top segment from tank 241-C-109 is 3.8 cm (1.5 in.) above the bit bottom to the waste surface. Segment recoveries were based on the maximum recoverable volume for the segment regardless of solid/liquid ratio. The maximum volume of the waste that can be contained in the samplers is 187 mL. Tables B2-1 and B2-2 present the initial measurements and observations regarding the core samples on extrusion, and an estimate of the core recovery on a volume basis.

Table B2-1. Tank 241-C-109 Core Sample Description Summary.

Core No.	Drill String Dose Rate R/hr	Total Mass g	Core Recovery (Volume Basis)	Comments
Core 47	1	134	70.1%	Liquid volume was 11 mL; it contained suspended solids. Solids portion was 26.7 cm (10.5 in.) long.
Core 48	2.5	73	33.3%	No liquid captured. Solids portion was 14.0 cm (5.5 in.) long.
Core 49	1.5	182	92.3%	Liquid volume was 22 mL. Solids were light brown in color with white streaks; Solid segment was 41.9 cm (13.5 in.) long.

Table B2-2. Tank 241-C-109 Core Sample Physical Characteristics Summary.

Core	Sample No.	Solids[1] Sample Mass g	Liquid[2,3] Sample Mass g	Solids[1] Sample Volume mL	Liquid[2,3] Sample Volume mL	Solids[1] Bulk Density g/mL	Liquids[2,3] Bulk Density g/mL
Core 47	92-069	121	13	103	11	1.2	1.1
Core 48	92-070	73	0	54	0	1.3	N/A
Core 49	92-071	158	24	128	22	1.1	1.1

Notes:

N/A = not analyzed

[1]Solids: wet solids
[2]Liquid: drainable (free) liquid
[3]All liquids were captured in the sample liner.

General characteristics of tank 241-C-109 waste materials are as follows:

- Drainable liquids (found in the liner) were brownish-yellow in color and contained suspended solids.

- Core samples were generally dark brown in color. The brown solids were streaked through with grey/white material.

- The samples had a firm consistency; they were thick, chunky sludges that held their shape after extrusion. The core materials all appeared to be saturated with liquid.

B2.1.2.1 Chain of Custody. A chain-of-custody record was kept during the sampling event for each segment that was sampled. The chain-of-custody form is a one-page record that is used to ensure that 1) the sample is safely and properly transported from the field to the laboratory, and 2) the correct personnel are involved in the sampling operation and transportation of the sample to the laboratory.

Copies of the chain-of-custody forms are on file at the Hanford Analytical Services Management (HASM) office, and are contained in the data package. No smearable contamination was found with these samples. However, from inspecting the chain-of-custody records, there appear to be irregularities in the sampling or transport of tank 241-C-109 samples. For example, some liner liquid was found in the core 47 and core 49 samples. The liquid found in the liners is assumed to be from the sampler. These irregularities merited a sample integrity concern and potential safety concern (that is, sample containment was compromised). Refinement and redesign of the sampler was implemented.

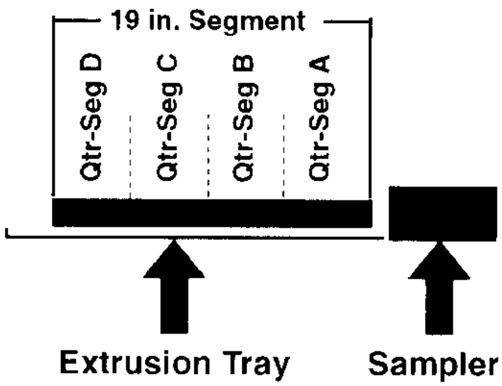
B2.1.2.2 Sample Breakdown Procedure. Because tank 241-C-109 was identified as a Watch List tank, more extensive analytical measurements were required to resolve the safety concerns associated with this tank. To enhance the resolution of the assays for key analytes, the analysis horizon for characterization was determined to be one-quarter of a segment.

Figure B2-1 illustrates how a segment sample is extruded and divided into subsegments. A video record of the extrusions of each of the segments from tank 241-C-109 was made, and color photographs documenting the extruded segments were taken.

B2.1.3 1992 Core Sample Analysis

The subsegment and core composite samples were homogenized using a mechanical mixer before analysis. This was done so that aliquots removed for analysis would be representative of the entire subsegment or core composite. Aliquots of the homogenized tank waste from Cores 48-1D and 49-1D were taken to determine the efficacy of the homogenization procedure. There was not sufficient sample material to perform a homogenization test on core 47.

Figure B2-1. Typical Single-Shell Tank Segment Extrusion.



The samples were split into duplicates, acid digested, and assayed by inductively coupled plasma-atomic emission spectroscopy (ICP) and gamma energy analysis. This procedure is done to determine if the degree of mixing achieved by the as-planned homogenization procedure was sufficient for the remaining samples to be homogenized and prepared for analysis. If the analytes from the aliquots are within a relative percent difference (RPD) of 10 percent, the samples are considered homogenized. If there are several analytes that are not within the specified RPD, the samples are mixed further and re-assayed. Once homogenization was indicated, the remaining samples were homogenized via the required procedure and prepared for analysis.

Core 48 showed significant differences between the means for the top and bottom segments for several major analytes (Na, Al, Ca, Ni, and P). In addition, large RPDs between the segment samples were observed for Fe, P, Si, and Mn. Results from the subsegment homogenization test compare well with the core composite values.

Core 49 showed no significant differences between the means for the top and bottom segments, but the test did show large RPDs for many elements, with much of the variation occurring in the top sample (RPDs ranging from 21 to 54 percent). These results indicate that acid digestion as a sample preparation was not appropriate, and that potassium hydroxide (KOH) fusion was required to dissolve this material. This behavior was not unexpected because the simulant materials were very resistant to dissolution.

Adequate amounts of Core 49 material remained to perform another homogenization test using a fusion dissolution sample preparation. The results from this test indicate that some difference remained between the top and bottom samples for Al and U, with Fe borderline (RPD near 20 percent). The RPDs between replicates for each sample were within established criteria, except for Mn, which is a trace analyte in this sample matrix. The KOH fusion preparation step appears to improve the homogenization test analytes, but the remaining differences between the top and bottom sample means indicate some non-homogeneity in the samples.

B2.1.3.1 Subsegment-level Analyses. The objectives of subsegment-level analyses were to provide 1) information as a function of depth pertaining to the overall waste energetics, 2) the distribution of ^{137}Cs and ^{90}Sr, 3) the concentration and solubility of the CN^- present in the sample, and 4) a higher resolution for determining bulk tank composition for certain analytes. To accomplish these goals, the limited suite of analyses listed in Table B2-3 were performed on each homogenized subsegment. These analyses were conducted using the analytical procedures identified in Tables I5-1 and I5-2 of Hill et al. (1991), and as amended in Hill (1991). Laboratory procedures used are described in detail in Simiele (1991).

Table B2-3. Subsegment-Level Analysis.

Direct	Fusion Dissolution	Water Leach
TOC/TIC TGA DSC Total CN^- Wt% H_2O	ICP (Metals) GEA (^{137}Cs) ^{90}Sr	IC (Anions) CN^- pH GEA

Notes:

DSC = Differential scanning calorimetry
GEA = Gamma energy analysis
ICP = Inductively coupled plasma - atomic emission spectroscopy
TGA = Thermogravimetric analysis
TIC = Total inorganic carbon
TOC = Total organic carbon

B2.1.4 1992 Core Sampling Analytical Result Summary

This section summarizes the 1992 sampling and analytical results for tank 241-C-109. The chemical, radiochemical, physical, and organic results associated with this tank are presented within this document as indicated in Table B2-4. The following subsections discuss the methods used in analyzing the core samples. Because of the large size of the data set, all discussion of the analytical procedures has been presented first, followed by the data tables.

Table B2-4. Analytical Presentation Tables.

Analysis	Table Number
Summary data for particle size analyses	B2-7 and B2-8
Summary data for physical properties	B2-9
Summary data for thermodynamic analyses	B2-10 through B2-13
Summary data for inorganic analyses	B2-14 through B2-60
Summary data for carbon analyses	B2-61 through B2-66
Summary data for radiochemical analyses	B2-67 through B2-84
Summary data for physical analyses	B2-85 through B2-87
Summary data for percent water analyses	B2-88
1994 vapor sampling data	B2-89
Historical sampling data	B2-90

The four quality control (QC) parameters assessed in conjunction with the tank 241-C-109 samples were standard recoveries, spike recoveries, duplicate analyses, and blanks. The QC criteria applied to the data, as outlined in DOE (1995), were 90 to 110 percent recovery for standards, 80 to 120 percent recovery for spikes (75 to 125 percent for metals), and ≤ 20 percent for the relative percent difference between duplicates. These criteria applied to all of the analytes. Sample and duplicate pairs in which any of the QC parameters were outside of these limits are footnoted in the sample mean column of the following data summary tables with an "a," "b," "c," "d," "e," or "f" as follows:

- "a" indicates that the standard recovery was below the QC limit.
- "b" indicates that the standard recovery was above the QC limit.
- "c" indicates that the spike recovery was below the QC limit.
- "d" indicates that the spike recovery was above the QC limit.
- "e" indicates that the RPD was above the QC limit.
- "f" indicates that there was blank contamination.

The following tables present the analytical results for the 1992 sampling event. All mean results presented in the tables were obtained by calculating an average concentration value from the initial and duplicate results. The free liquids from Cores 47 and 49 were combined and analyzed as a separate liquid core composite. If an analyte was detected in the original but not in the duplicate, or if both sample results were nondetect, the mean was reported as a nondetect.

B2.1.5 1992 Core Sample Analytical Methods Description

B2.1.5.1 Sample Preparation Methods. The characterization plan (Hill et al. 1991) required that anions, metals, and several radionuclides be analyzed. Metals were determined following three different sample treatments: 1) water leach; 2) acid digestion; and 3) potassium hydroxide fusion. The anions were prepared by water extraction. The radionuclides were analyzed by water and fusion digestion.

Water leach (or water digestion) analyses are assays performed after the sample matrix has been digested in distilled/deionized water; the water is then analyzed for soluble analytes. The soluble anions are determined by ion chromatography (IC). The primary anions analyzed in this manner are fluoride, chloride, nitrate, nitrite, phosphate, and sulfate. In addition, free cyanide and pH were also analyzed from water digestion samples.

Selected radionuclides were measured on some of the water digestion samples to determine the type and number of water soluble radionuclides. Atomic absorption (AA) and ICP spectroscopy were also performed on some of the water digestion samples. These assays were performed to determine the amount of soluble metal cations (ICP) or arsenic, mercury, or selenium (AA). In most cases, these analytes were below the detection limits in the water digestion samples, suggesting that many of the analytes are not water soluble.

Acid digestion is a preparation method where the sample is dissolved in a mixture of nitric and hydrochloric acids. This preparation brings most of the insoluble metals into a solution with a minimum amount of dilution, and is usually best for the detection of trace and some major metals. These properties are the reason that acid digestion is generally used as the sample preparation for the homogenization tests. The analyses performed on this preparation were ICP, GEA, and AA (the AA analysis used nitric acid only). The IC analysis was not performed with the acid digestion preparation solution.

Analyses that were performed on fusion-prepared samples were ICP and GEA. Fusion dissolution analyses are assays performed on the sample matrix after it has been fused with potassium hydroxide in a crucible (nickel crucibles were used) and dissolved in acid. This preparation dissolves the entire sample, whereas other sample preparation procedures may not completely dissolve the sample matrix.

However, one significant disadvantage of fusion preparation is that large amounts of potassium hydroxide are required to bring a sample into solution. Because of the high dilution factor, trace elements are less likely to be correctly quantified if they are detected at all. Elements that occur in abundance (major metals) or are highly insoluble are likely to be detected better by the fusion results than by any other sample preparation. Generally, fusion dissolution is the preferred method of analyzing radionuclide content, with the exception of ^{14}C and ^{3}H (tritium).

In this case, the sample preparation specified in the test instructions for ^{14}C (water digestion) is likely not the best for the ferrocyanide waste. Difficulty with dissolving the sample with a water leach, and volatility associated with a fusion preparation will bias the ^{14}C results low for both sample preparations. An adequate sample preparation method for ^{14}C is not available for this sample matrix; however, ^{14}C is not expected to be a significant contributor to the radionuclide content of the waste.

A zirconium crucible was initially recommended for use with these assays to eliminate any potential nickel bias, but the sample matrix reacted with the zirconium during the initial fusion procedure and a nickel crucible was subsequently used. Potassium readings from the ICP fusion are not reported because potassium hydroxide was used to dissolve the sample and the potassium results are not important to characterizing the waste. Some of the primary radionuclides that are measured using this sample preparation are neptunium, plutonium, strontium, cesium, and technetium. A total alpha and total beta count were performed on the fusion dissolution samples as well.

Direct analyses are assays performed on the sample matrix with little or no sample preparation. Several direct analyses were performed relating to the energetic properties of the waste: total organic carbon (TOC), scanning TGA, DSC, cyanide, and gravimetric weight percent water

B2.1.5.2 Graphite Furnace Atomic Absorption Spectroscopy. In addition to ICP, arsenic, antimony, and selenium were determined by graphite furnace atomic absorption spectroscopy according to procedures PNL-ALO-214, PNL-ALO-219, and PNL-ALO-215, respectively. The results are presented in Tables B2-14 through B2-16.

B2.1.5.3 Cold Vapor Atomic Absorption Spectroscopy. Mercury was analyzed by cold vapor atomic absorption spectroscopy according to procedure PNL-ALO-213. The results are presented in Table B2-17.

B2.1.5.4 Inductively Coupled Plasma Spectroscopy. The following analytes were evaluated by ICP according to procedure PNL-ALO-211: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, cerium, chromium, cobalt, copper, dysprosium, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, neodymium, nickel, potassium, phosphorus, rhenium, rhodium, ruthenium, silicon, silver, sodium, strontium, tellurium, thallium, thorium, titanium, uranium, vanadium, zinc, and zirconium.

Major metals that were well quantified with fusion ICP analysis for tank 241-C-109 were aluminum, calcium, iron, lead, sodium, and uranium. Phosphorous and silicon are non-metallic analytes detected by ICP. In the case of these elements the value from the fusion sample preparation is the more accepted quantity. Aluminum, iron, phosphorus, and sodium were the most abundant metals in tank 241-C-109. The results are presented in Tables B2-18 through B2-51.

B2.1.5.5 Ion Chromatography. The following anions were determined by ion chromatography (IC) according to procedure PNL-ALO-212: chloride, fluoride, nitrate, nitrite, phosphate, and sulfate. All of the analytes were present in tank 241-C-109. The results are presented in Tables B2-52 through B2-57.

B2.1.5.6 Distillation/Spectrophotometric Analysis. Total cyanide analysis was done using procedure PNL-ALO-271 developed at PNNL for these types of samples. The sample was dissolved in a solution of ethylenediaminetetraacetic acid and ethylenediamine and placed in a microdistillation apparatus. The total cyanide content was determined by argentometric titration. The results are presented in Table B2-58.

B2.1.5.7 Ammonia By Ion Selective Electrode. The ammonia analysis was performed by procedure PNL-ALO-226. The results are presented in Table B2-59.

B2.1.5.8 Chromium (VI) By Spectrophotometric Analysis. Analyses for chromium (VI) were performed by spectrophotometry on composite samples which had been water leached. The analyses were performed according to procedure PNL-ALO-227. Results from this analysis are shown in Table B2-60.

B2.1.5.9 Carbon. Total inorganic carbon (TIC), total organic carbon (TOC), total carbon (TC), total extractable organic halides (TOX), and semivolatile organic constituents were required analytes of the 1992 samples. The TOC was determined using the hot persulfate method. A sample is dissolved in a sulfuric acid solution (90+ °C) to liberate inorganic carbon (carbonate). Potassium persulfate ($K_2S_2O_8$) is then added, and organic carbon is converted to CO_2, which is measured coulometrically. The total organic and inorganic carbon assays are not considered capable of reliably detecting carbon contained in cyanide compounds for these waste matrices.

A U.S. Environmental Protection Agency Contract Laboratory Procedure (CLP) type organics speciation analysis was performed on the core composites. No CLP target compounds or tentatively identified compounds were detected in levels above accepted quantitation limits (Bell 1993) and they were not expected to contribute to the sample matrix.

The following subsections discuss these results.

B2.1.5.10 Total Carbon. Total carbon was determined by persulfate oxidation as established in procedure PNL-ALO-381. The results are presented in Table B2-61.

B2.1.5.11 Total Inorganic Carbon. Total inorganic carbon was determined by persulfate oxidation as established in procedure PNL-ALO-381. The results are presented in Table B2-62.

B2.1.5.12 Total Organic Carbon. Total organic carbon was determined by persulfate oxidation using procedure PNL-ALO-381. The results are presented in Table B2-63.

B2.1.5.13 Total Extractable Organic Halides. Total extractable organic halides were determined by using procedure PNL-ALO-320. The results are presented in Table B2-64.

B2.1.5.14 Semivolatile Organic Compounds. Semivolatile organic compounds were determined according to procedure PNL-ALO-345. The results are presented in Tables B2-65 and B2-66.

B2.1.5.15 Laser Fluorimetry. Total uranium was determined by laser fluorimetry according to procedure PNL-ALO-445. The sample results are presented in Table B2-67.

B2.1.5.16 Isotopic Uranium and Plutonium by Mass Spectrometry. Mass spectrometry was used to determine the isotopic distribution of uranium and plutonium according to procedure PNL-ALO-455. The sample results are presented in Tables B2-68 and B2-69.

B2.1.5.17 Alpha Spectrometry. The following were evaluated by alpha spectrometry according to procedure PNL-ALO-421: ^{237}Np, ^{241}Am, and total alpha activity. The sample results are presented in Tables B2-70 through B2-73.

B2.1.5.18 Beta Proportional Counting. Beta proportional counting was used to determine total beta activity, ^{90}Sr, and ^{99}Tc activity according to procedure PNL-ALO-431. The sample results are presented in Tables B2-74 through B2-76.

B2.1.5.19 Gamma Energy Analysis. The activities of the following radionuclides were determined by GEA according to procedure PNL-ALO-451: ^{241}Am, ^{137}Cs, ^{60}Co, and $^{154/155}$Eu. The results from the gamma analyses are presented in Tables B2-77 through B2-81.

B2.1.5.20 Liquid Scintillation. Tritium, ^{14}C, and ^{79}Se were analyzed by liquid scintillation according to procedures PNL-ALO-443, PNL-ALO-444, and PNL-ALO-442 respectively. The sample results are presented in Tables B2-82 through B2-84.

B2.1.5.21 Rheological and Physical Measurements. Only one 25-mL aliquot (from Core 47) was used for the full suite of rheological and physical measurements. Viscosity, settling properties, fluid behavior, and shear strength were some of the primary characteristics investigated. The sample tested for these properties was not homogenized before analysis. Some selected physical measurements were performed on all of the core composites.

At the time of the sampling and analysis of tank 241-C-109, no DQO existed to define the scope of the analyses. However, several analytes relating specifically to physical properties were determined to be of interest to the waste characterization program and are summarized here. Data regarding the physical characteristics of tank waste are necessary for the design and fabrication of retrieval, pretreatment, and final waste disposal systems.

B2.1.5.22 Density. Upon extrusion, a density calculation was made for each segment from both cores by dividing the mass recovered for that segment by its volume. These values are reported in Table B2-85.

B2.1.5.23 Weight Percent Solids. A gravimetric determination of weight percent solids for all core composites and subsegments was performed, and the results presented in Table B2-86. The gravimetric weight percent water was determined by drying the sample for 12 to 24 hours in an oven at 103 to 105 °C (217 to 221 °F) and measuring the difference in the weight of the sample.

B2.1.5.24 Shear Strength. The shear strength of the waste from tank 241-C-109 was measured on a combined, unhomogenized sample from core 47. The shear strength measurements were made at ambient temperature using a shear vane connected to a viscometer and rotated at 0.3 revolutions per minute (rpm).

Shear strength (τ_s) is a semiquantitative measurement of the force required to move the sample. Because shear strength is dependent on sample handling, the measurement was taken without any sample homogenization. The rheology sample was generated by taking small aliquots from the segment of core 47 at various positions.

Two measurements of τ_s were taken, averaging 17,300 dynes/cm^2 (17,560 and 17,000 dynes/cm^2). The shear stress of the material exceeded the maximum value for the measurement system (8,500 Pa). To take a measurement, the core was rotated at a significantly higher rate than was used in the τ_s measurement, causing the measured shear stress to be higher than the actual value. In addition, some drying of the sample may have occurred, also causing the measurement to be higher than its true value.

A rheogram for a material with a yield stress has two sections. The first section is a straight line beginning at the origin and climbing up the ordinate. This portion of the rheogram records the material as it acts like a solid or gel. When sufficient force is applied to the material to make the gel yield, the rheogram breaks sharply to the right and records the material's behavior as a fluid. The point on the rheogram at which the sample's behavior transfers from a solid or gel to a fluid is the yield point or yield stress. The consistency factor in this model is analogous to viscosity. The flow behavior index indicates the degree of deviation from Newtonian behavior. For values less than 1, the behavior is considered pseudoplastic (Bird et al. 1960). Plots of all of the measurements can be found in the full validated data package (Bell 1993).

B2.1.5.25 Shear Stress and Viscosity. Shear stress and viscosity measurements (as functions of shear rate) were performed on the 1:1 (water:sample) dilution of the sample at ambient hot cell temperatures 29 to 32 °C (84 to 90 °F) and at 95 °C (203 °F). Drying of the sample at 95 °C (203 °F) posed difficulties in measurement for the 1:1 diluted sample; no results of the rheograms run under these conditions are presented. The data from the rheograms for the 1:1 dilution were fit to a nonlinear yield power-law model:
where:

$$S_\tau = \alpha + \beta\gamma^n$$

S_τ = Shear stress
α = Yield stress (not a fit parameter)
β = Consistency factor
γ = Shear rate (0 to 468 s^{-1})
n = Flow behavior index

Table B2-5 presents the power law model parameters for the 1:1 sample dilutions at 30 °C (86 °F).

Table B2-5. Power-Law Model Parameters for Tank 241-C-109 Material.

Sample	Temperature (°C)	Trial	α, Yield Stress (Pa)	β, Consistency Factor (Pa• s)	n, Flow Behavior Index
1:1 Dilution	30	S	50	0.017	1
1:1 Dilution	30	D	40	0.019	1

Notes:
S = sample
D = duplicate.

Viscosity of the 1:1 diluted sample at low shear (that is, near zero) ranged between 2,800 and 4,200 cP; the viscosity gradually declined with increasing shear rates to 100 cP at 468 s^{-1}. The 1:1 dilution of the composite sample exhibited yield-pseudoplastic behavior. Figures B2-2 and B2-3 present data smoothed results for shear stress versus shear rate and viscosity versus shear rate for the 1:1 diluted sample.

The 3:1 dilution samples exhibit near Newtonian behavior at the detection limit of the system (2 cP) for shear stress as a function of shear rate. Viscosity of the 3:1 diluted sample at low shear ranged between 12 and 42 cP (avg. ~30 cP); the viscosity rapidly declined with increasing shear rates to approximately 5 cP at 100 s^{-1} and 3 cP at 468 s^{-1}. Higher viscosities at higher temperatures for these sample matrices is not unusual, because drying of the sample often has a significant impact on its flow behavior.

Figure B2-2. Shear Stress vs. Shear Rate for 1:1 Diluted Sample.

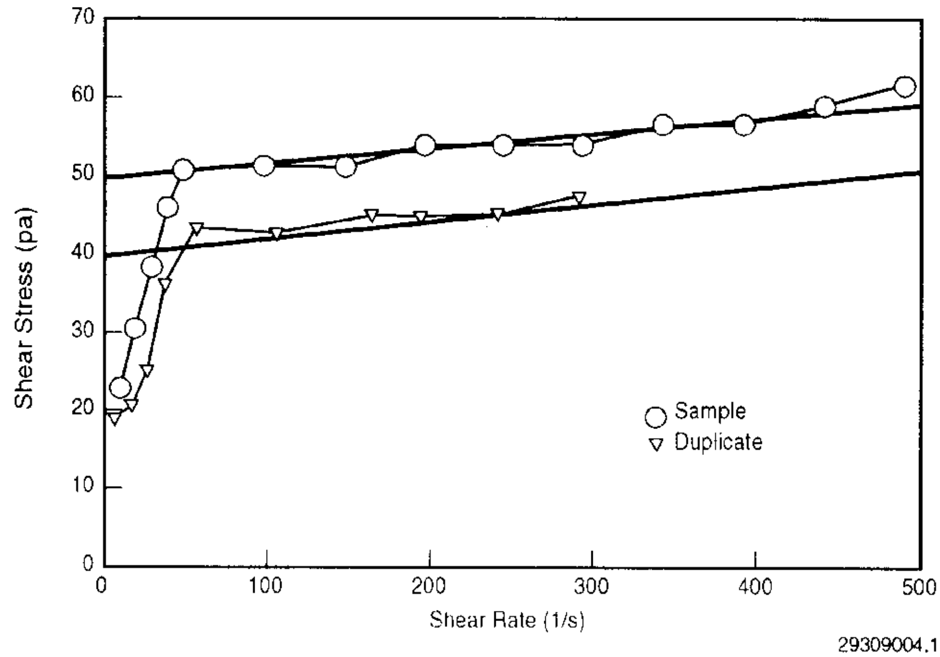
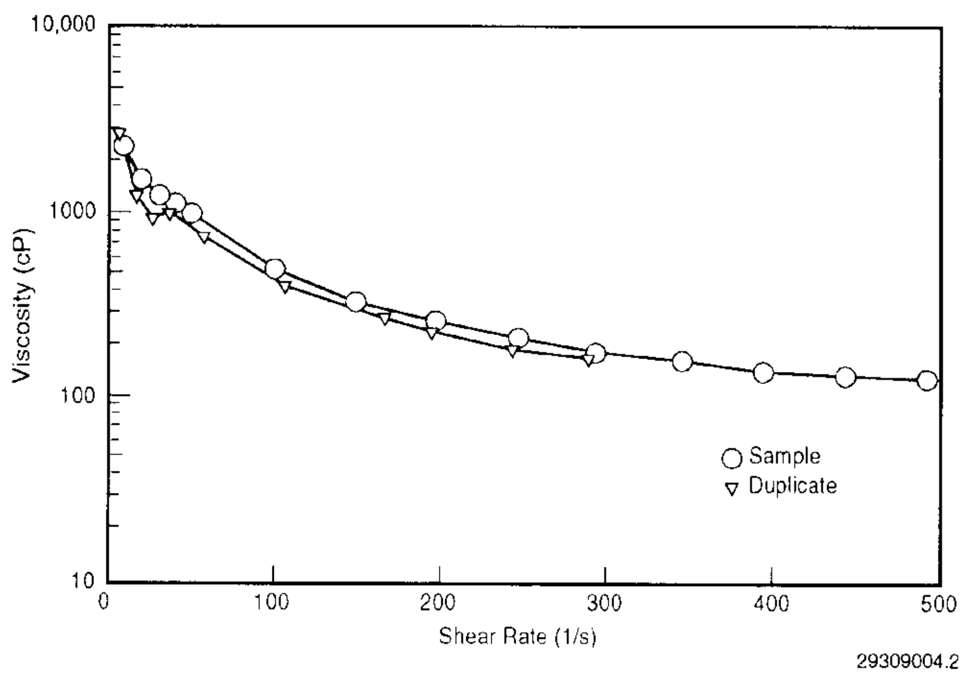


Figure B2-3. Apparent Viscosity vs. Shear Rate for 1:1 Diluted Sample.



Further measurements of the viscosity as a function of shear rate were made on the 3:1 dilution samples at 95 °C (203 °F). The 3:1 dilution samples exhibit near Newtonian behavior at the detection limit of the system (2 cP) for shear stress as a function of shear rate. Viscosity of the 3:1 diluted sample at low shear ranged between 37 and 95 cP (avg. ~58 cP). The viscosity rapidly declines with increasing shear rates to between 5 and 12 cP at 100 s^{-1} and approximately 3 cP at 468 s^{-1}.

B2.1.5.26 Slurry Flow Properties. Turbulent flow is necessary to keep particles in suspension and prevent the accumulation of the solids in retrieval and/or pretreatment process equipment. Characteristics necessary for turbulent flow were calculated for the 1:1 dilution slurry using the parameters determined from measurement and a curve-fitted rheological model (Bell 1993) (refer to Table B2-6).

Table B2-6. Turbulent Flow Model Calculations.

Sample	Temp. °C	Trial	Pipe Diameter in.	Velocity m/s	Critical Flow Rate L/min	Reynolds Number
1:1 Dilution	30 (86 °F)	S	2 (5.08 cm)	3.26	424	12,800
	30 (86 °F)	D	2 (5.08 cm)	3.14	405	16,900
	30 (86 °F)	S	3 (7.62 cm)	2.90	833	16,900
	30 (86 °F)	D	3 (7.62 cm)	2.77	799	14,400

Notes:

m/s = meters per second
S = sample
D = duplicate.

B2.1.5.27 Particle Size Measurement. Particle size analysis was performed by placing a small amount of sample in a dispersant, which is the liquid used to disperse and suspend the particles from the solid sample. Samples from all three cores (cores 47, 48, and 49) were prepared and assayed. The prepared sample was placed in a particle size analyzer, which measures particle size by passing a thin beam of laser light through the dispersant.

The diameter of a particle of matter in the dispersant can be determined by the amount of light that it blocks as the particle passes through the beam. The dimension measured by this method is the value across the short diameter of the particle. This means that if a particle is oblong, the machine estimates the shortest length across the particle (that is, the width of the oblong shape, not the length).

The mean particle size in the number distribution ranged from 0.80 to 1.38 μm in diameter for 241-C-109 tank waste samples. Table B2-7 presents the summary results of the measurements. Plots of the probability number density for each core are presented as Figures B2-4, B2-5, and B2-6 as a number fraction. The number density graph is plotted over the acquisition range of the device (from 0.5 to 150 μm). The numbers of particles in each size ranged (shown as a percentage of the whole) are graphed against their respective size ranges to form a distribution curve. It can be seen from the figures that the most common occurrences (modes) for particle size ranged between 0.5 and 1.0 μm. The majority (over 88 percent) of the measured particles fit within the narrow band of 0.0 to 2.0 μm.

Table B2-7. Particle Size Distribution by Number: 89 Percent < 2 μm (All Cores).

Sample	Mean (μm)	Median (μm)
Core 47	1.14	0.85
Core 48	0.8	0.77
Core 49	1.38	0.9

The particle size in the volume distribution ranged from 0.0 to 70 μm in diameter between the three cores with relatively wide variation between the means (5.73 to 37.56 μm). Table B2-8 presents the summary results of the measurements. Under the assumption that the density of the solid material within the tank is constant, the volume distribution is the best estimation of the mass particle size distribution of the tank. The analyzer calculates particle volume as the cube of the diameter. These distributions are presented as Figures B2-7, B2-8, and B2-9.

Table B2-8. Particle Size Distribution by Volume: 100 Percent < 70μm (All Cores).

Sample	Mean (μm)	Median (μm)
Core 47	37.56	38.72
Core 48	5.73	2.97
Core 49	24.47	24.08

Figure B2-4. Core 47, Particle Size Number Density.

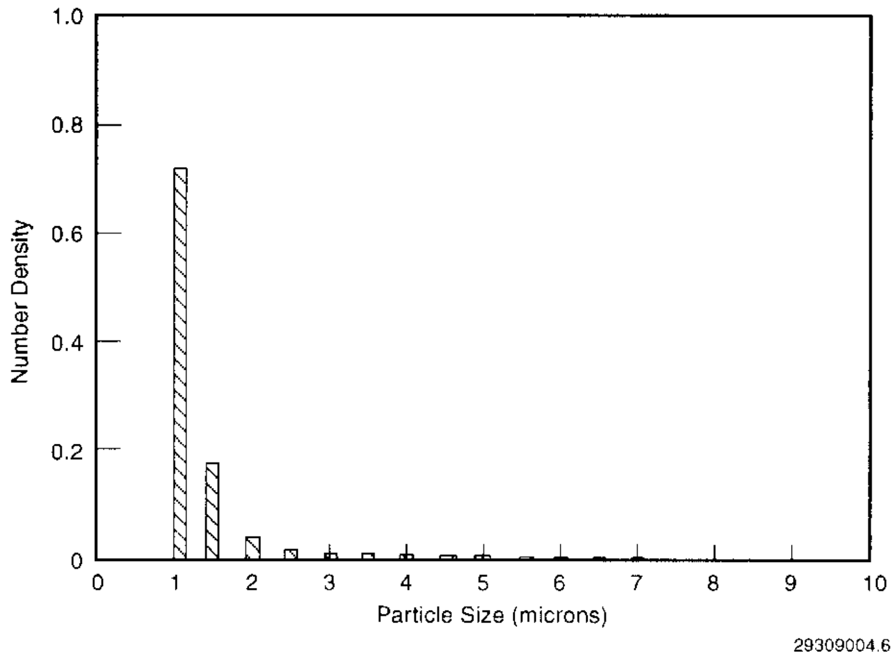


Figure B2-5. Single-Shell Tank Core 47, Particle Size Volume Density.

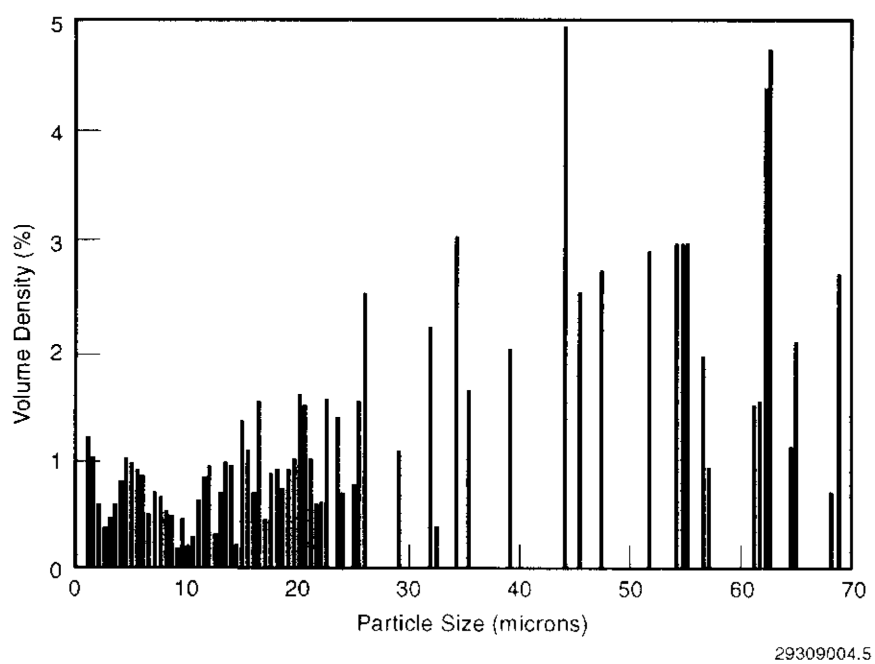


Figure B2-6. Core 48, Particle Size Number Density.

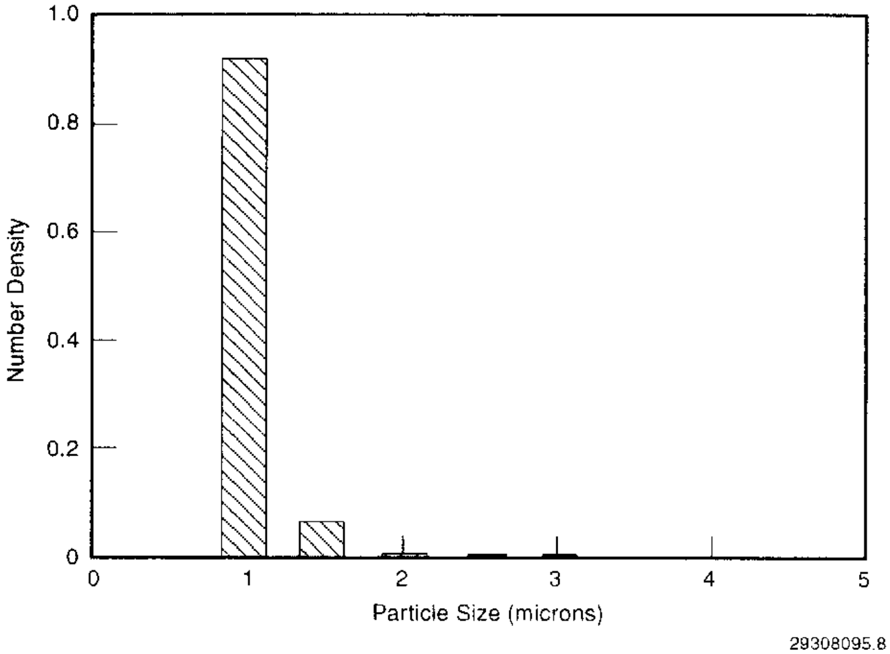


Figure B2-7. Single-Shell Tank Core 48, Particle Size Volume Density.

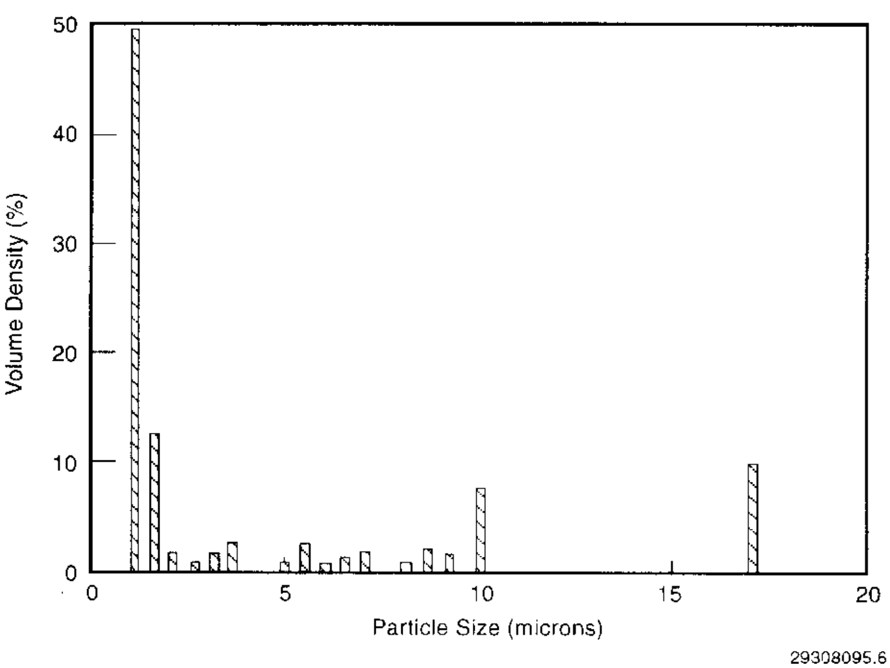


Figure B2-8. Core 49, Particle Size Number Density.

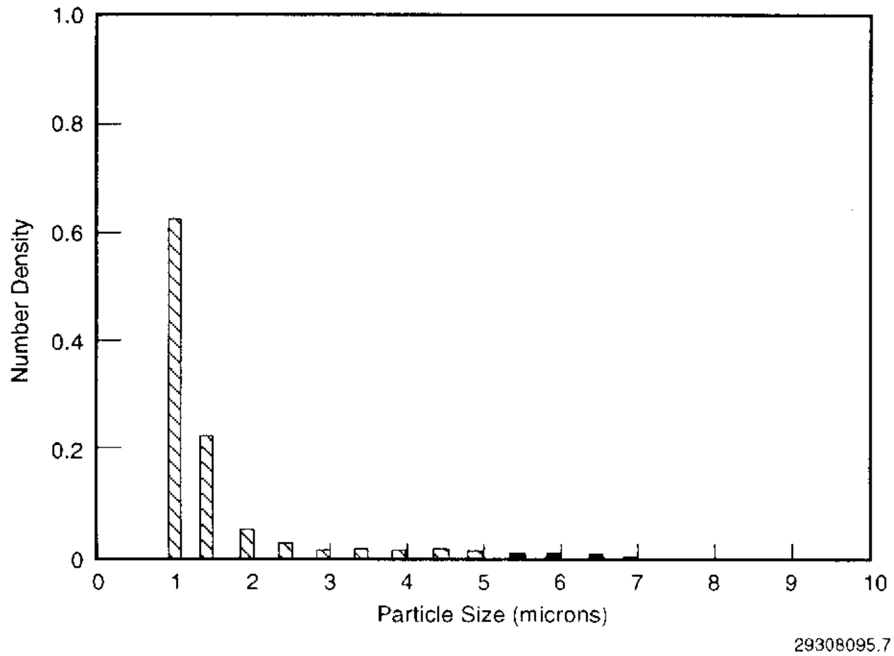
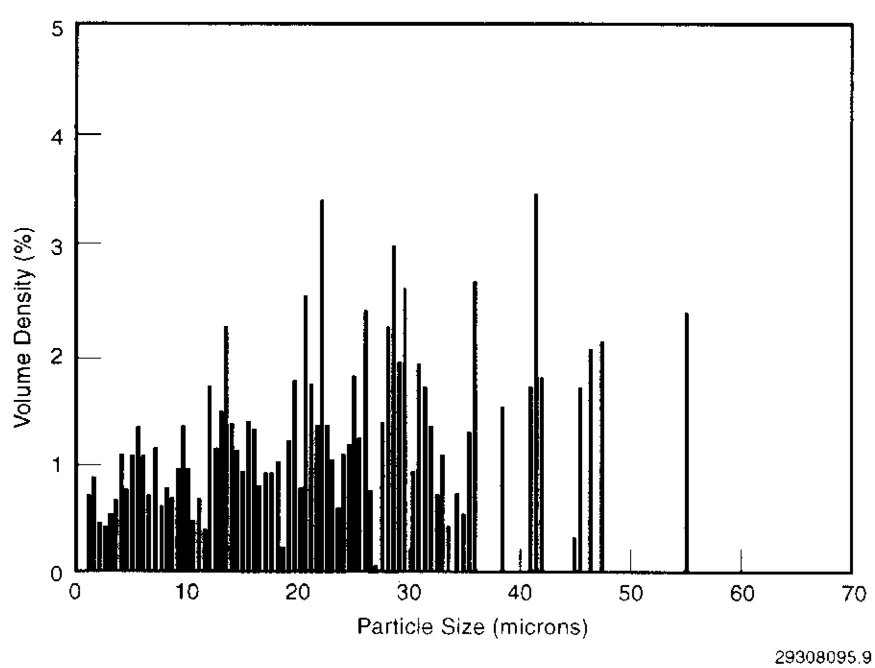


Figure B2-9. Single-Shell Tank Core 49, Particle Size Volume Density.



The volume distribution is represented by a percentage on a probability volume density graph. The average particle size represented in the volume distribution is considerably larger than that in the number distribution. In core 47 there are relatively few small particles, as most of the particle volume is evenly dispersed within the 10.0 to 70.0 μm range. In core 48 the majority of the particles are much smaller, with particle volumes concentrated in two narrow ranges, the 0.0 to 2.0 μm range, and the 9.0 to 20.0 μm range. Core 49 is quite similar to core 47, in that there are relatively few small particles, most of the particles are evenly dispersed within the 10.0 to 60.0 μm range. The disparity between the core sample measurements possibly indicates a difference in waste type. In core 48, over 50 percent of the volume is contained in particles with a diameter of less than 3 μm. In cores 47 and 49, over 50 percent of the particle volume is contained in material with a diameter greater than 20 μm.

In the retrieval and subsequent treatment of the tank wastes, it may be desirable to design pumping or filtration systems for the tank particulate. Therefore, the volume distribution of the particles should not be neglected (that is, particles with diameters of over 20 μm should be considered in these designs). In addition, the behavior of the particle size distribution is believed to have an impact on analytical precision, especially with small sample sizes and should be considered when evaluating analytical results.

B2.1.5.28 Settling Behavior of As-Received and Diluted Samples. This section analyzes the settling behavior for the as-received, 1:1, and 3:1 water:sample dilutions. The physical properties reported here include settling rates and volume percent settled solids, and weight percent and volume percent centrifuged solids. The experimental procedures used to perform these measurements were reported previously (Bell 1993). The physical properties of the core 47 material and diluted samples are summarized in Table B2-9.

Table B2-9. Physical Properties Summary.

Property	As-Received	Segment	
		1:1 Dilution	3:1 Dilution
Settled solids (vol%)	100%	88%	41%
Centrifuged solids			
Vol%	100%	Not measured	21.1
Wt%	100%	Not measured	27.0
Density (g/mL)			
Sample[1] solid liquid	1.2 - 1.3 1.1 - 1.2	Not measured	1.11
Centrifuged supernatant	Not measured	Not measured	1.01
Centrifuged solid	Not measured	Not measured	1.39

Notes:

[1]Obtained from bulk measurements.

Because there was no free liquid with the waste in the sampler, no settling was observed in the as-received segment samples over a period of three days and there was no standing liquid obtained with the samples. Two dilutions (1:1 and 3:1 water to sample) were prepared, and the volume percent of settled solids for each of the dilutions are plotted as a function of settling time. Figures B2-10 and B2-11 illustrate the setting behavior over time.

The 1:1 dilution reaches a final volume percent settled solids of 88 percent (average). Settling continues throughout the 3-day period, but the majority of the settling is seen in the first 24 hours. The 3:1 dilution reaches a final volume percent settled solids of 41 percent (average). The majority of the solids settling is complete within 10 hours.

B2.1.5.29 pH. The pH of the samples was measured according to procedure PNL-ALO-501. The results are presented in Table B2-87.

B2.1.5.30 Differential Scanning Calorimetry. In a DSC analysis, heat absorbed or emitted by a substance is measured while the temperature of the sample is heated at a constant rate. A gas such as nitrogen or air is passed over the sample material to remove any gases being released. The onset temperature for an endothermic or exothermic event is determined graphically. The results from the DSC analysis are presented in Table B2-10 and are compared to theoretical energy releases in Table B2-11. The DSC analyses were performed according to procedure RDS-TA-1.

The properties related to energetics are illustrated for each core in Table B2-12. The results for the samples from 48-1D, indicates that this sample differs in thermal behavior from most of the other samples, further suggesting a difference in waste type.

The TIC and TOC assays are not considered capable of measuring the total cyanide in the waste because they depend on acid dissolutions to perform the analyses.

B2.1.5.31 Thermogravimetric Analysis. Thermogravimetric analysis measures the mass of a sample while its temperature is increased at a constant rate. Nitrogen (or air) is passed over the sample during heating to remove any released gases. Any decrease in the weight of a sample during TGA represents a loss of gaseous matter from the sample, either through evaporation or through a reaction that forms gas phase products. The moisture content is estimated by assuming that all TGA sample weight loss up to a certain temperature (typically 150 to 200 °C [300 to 390 °F]) is due to water evaporation. The temperature limit for moisture loss is chosen by the operator at an inflection point on the TGA plot. Other volatile matter fractions can often be differentiated by inflection points as well.

Gravimetric analysis was also used to determine the weight percent water. The gravimetric determination of the weight percent water is measured by the loss of mass in the sample after being held in a drying oven at 105 °C (221 °F) for 12 to 24 hours. Results are summarized in Table B2-13. The complete data set can be found in Table B2-88.

Figure B2-10. Settling Rate Data for Tank 241-C-109 Core 49, 1:1 Dilution.

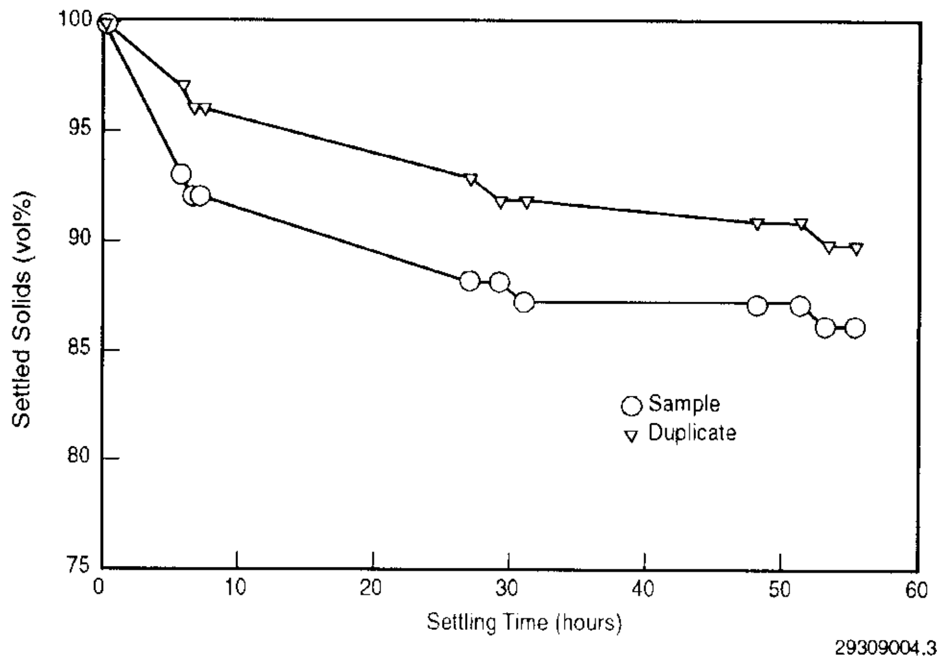


Figure B2-11. Settling Rate Data for Tank 241-C-109 Core 49, 3:1 Dilution.

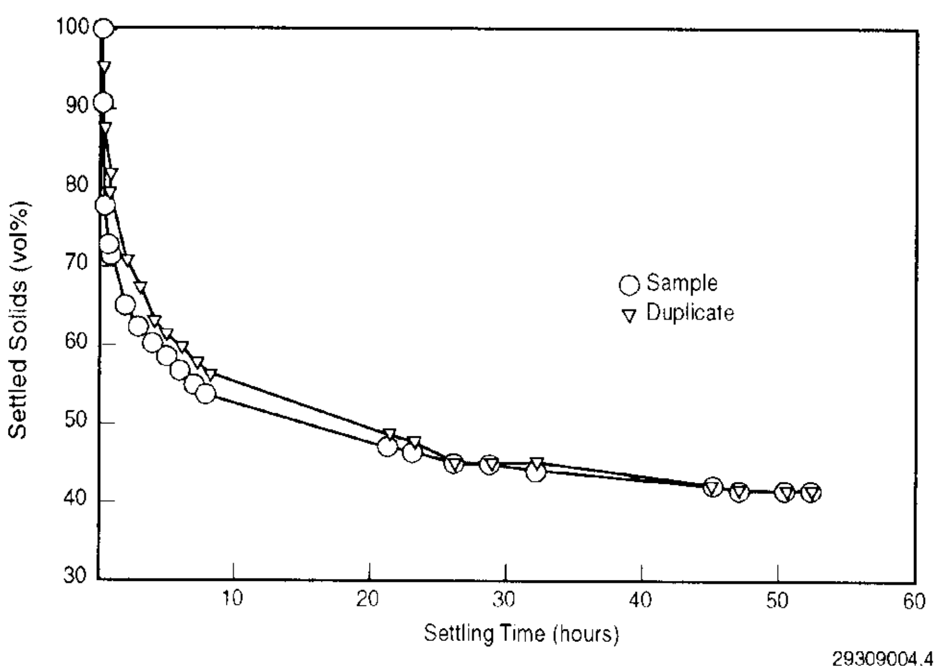


Table B2-10. Differential Scanning Calorimetry Energetics Results from Tank 241-C-109.

Core Sample	Transition 1			Transition 2			Transition 3		
	Range	Avg. Onset	Avg. ΔH	Range	Avg. Onset	Avg. ΔH	Range	Avg. Onset	Avg. ΔH
	°C	°C	J/g	°C	°C	J/g	°C	°C	J/g
Core 47									
47-1B	33-150	70	350	190-338	259	1,555	(a)[1]	n/a	---
47-1C	35-144	53	425	167-318	217	610	380-461	391	72
47-1D	34-154	59	767	190-369	225	508	369-441	375	21
47-Comp.	34-150	55	785	159-330	216	1,084	(a)[1]	n/a	---
Core 48[2]									
48-1D	34-196	104	1,034	249-338	272	-27	336-431	359	31
Core 49									
49-1B	33-115	40	368	193-373	270	2,188	(a)[1]	n/a	---
49-1C	33-197	72	658	167-316	242	565	(a)[1]	n/a	---
49-1D	34-166	71	712	152-324	225	305	379-483	394	48
49-Comp.	34-192	99	964	190-329	243	922	(a)[1]	n/a	---

Notes:

n/a = not applicable

[1](a) No quantifiable transition is observed.

[2]Core 48 had 4 transitions. Transition 1A: Temp. Range 185 to 255 °C (365 to 491 °F); Onset Temp. 198 °C (388 °F); ΔH= 15 J/g

To convert from J to calories, divide by 4.18.

Negative ΔH indicates an exotherm.

Table B2-11. Tank 241-C-109 Energetic Comparison.

Subsegment	Wt% Total Cyanide (Dry)	Equivalent Wt% Sodium Nickel Ferrocyanide (Dry)	Theoretical Heat of Reaction (cal/g Dry Waste)[1]	Measured Heat of Reaction (cal/g Dry Waste)
Core 47				
1B	0.30	0.61	-5.8	No Exotherm
1C	0.44	0.89	-8.4	No Exotherm
1D	0.58	1.17	-11.1	No Exotherm
Composite	0.55	1.11	-10.5	No Exotherm
Core 48				
1C	1.13	2.29	-21.6	No measurement
1D	0.87	1.76	-16.6	-12.4
Composite	1.44	2.91	-27.5	No measurement
Core 49				
1B	0.35	0.71	-6.7	No Exotherm
1C	0.81	1.64	-15.5	No Exotherm
1D	0.55	1.11	-10.5	No Exotherm
Composite	0.56	1.13	-10.7	No Exotherm

Notes:

1 cal = 4.18 Joule

[1]Based on -3.95 kJ/g $Na_2NiFe(CN)_6$ (Fauske 1992).

Table B2-12. Tank 241-C-109 Energetics Trending.

Subsegment	Wt% Total Cyanide (Dry)	Wt% Total Organic Carbon	Wt% Total Carbon	Wt% Water (Grav.)[2]	Wt% Water (TGA)	Average Heat of Reaction[1] (J/g dry waste)
Core 47						
1B	0.30	0.22	0.76	19.3	31.4	No Exotherm
1C	0.44	0.20	0.72	28.4	39.3	No Exotherm
1D	0.58	0.22	0.76	39.4	28.2	No Exotherm
Composite	0.55	0.23	0.80	21.5	33.4	No Exotherm
Core 48						
1C	1.13	0.37	1.24	52.8	NM	NM
1D	0.87	0.35	1.10	51.6	48.1	-51.9
Composite	1.44	0.31	0.87	57.7	NM	NM
Core 49						
1B	0.35	0.18	0.57	19.6	34.1	No Exotherm
1C	0.81	0.22	0.88	38.3	46.6	No Exotherm
1D	0.55	0.26	0.94	39.6	40.0	No Exotherm
Composite	0.56	0.23	0.67	27.8	46.1	No Exotherm

Notes:

NM = no measurement
1 cal = 4.18 J

[1]Heats of reaction are calculated using the TGA weight percent water value.
[2]Grav. = Water content from gravimetric weight percent water.

Table B2-13. Thermogravimetric Analysis Results from Tank 241-C-109.

Core Sample	Total Wt% Loss	Transition 1 Wt% Loss	Transition 2 Wt% Loss	Transition 3 Wt% Loss
Core 47				
47-1B	31.4	10.2	17.9	3.3
47-1C	39.3	18	17.6	3.7
47-1D	28.2	19.7	6.8	1.7
47-Comp.	33.4	14.8	14.9	3.7
Core 48				
48-1C	No measurement	No measurement	No measurement	No measurement
48-1D	48.1	45.1	3.2	-0.2
48-Comp.	No measurement	No measurement	No measurement	No measurement
Core 49				
49-1B	34.1	4.2	25.8	4.1
49-1C	46.6	29.6	14.2	2.8
49-1D	40.0	29.3	9.6	1.1
49-Comp.	46.1	26.6	15.8	3.7

B2.1.6 Analytical Data Tables

Table B2-14. Tank 241-C-109 Analytical Results: Arsenic (AA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01358-B1	Core 47	Solid composite	73	89	81
93-01363-B1	Core 48	Solid composite	1.4	2.3	1.9[QC:c,e]
93-01371-B1	Core 49	Solid composite	118	110	114

Table B2-15. Tank 241-C-109 Analytical Results: Antimony (AA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01358-A1	Core 47	Solid composite	< 3.1	< 3.2	< 3.2
93-01363-A1	Core 48	Solid composite	< 0.6	< 0.6	< 0.6[QC:c]
93-01371-A1	Core 49	Solid composite	< 2.9	< 2.9	< 2.9

Table B2-16. Tank 241-C-109 Analytical Results: Selenium (AA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01358-B1	Core 47	Solid composite	< 2.4	< 2.4	< 2.4
93-01363-B1	Core 48	Solid composite	< 2.4	< 2.5	< 2.5
93-01371-B1	Core 49	Solid composite	< 2.3	< 2.3	< 2.3

Table B2-17. Tank 241-C-109 Analytical Results: Mercury (CVAA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			**µg/g**	**µg/g**	**µg/g**
93-01358-D1	Core 47	Solid composite	8.5	9.2	8.9[QC:d]
93-01363-D1	Core 48	Solid composite	6.5	6.6	6.6
93-01371-D1	Core 49	Solid composite	6.5	6.8	6.7
Drainable liquid: direct filtered			**µg/g**	**µg/g**	**µg/g**
93-01354-N1	Tank composite	Liquid composite	0.09	0.092	0.091[QC:d]

Table B2-18. Tank 241-C-109 Analytical Results: Aluminum (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			μg/g	μg/g	μg/g
93-01361-A1T	48: 1	Subsegment D Upper half	9,042	7,866	8,454
93-01361-A1T		Subsegment D Upper half	8,725	7,891	8,308
93-01361-A1B		Subsegment D Lower half	9,451	8,838	9,144.5
93-01361-A1B		Subsegment D Lower half	9,348	8,964	9,156
93-01367-A1T	49: 1	Subsegment D Upper half	39,692	46,756	43,224
93-01367-A1T		Subsegment D Upper half	39,402	46,588	42,995
93-01367-A1B		Subsegment D Lower half	41,757	46,801	44,279
93-01367-A1B		Subsegment D Lower half	42,056	47,875	44,965.5
93-01358-A1		Solid composite	74,113	71,614	72,863.5
93-01363-A1	Core 48	Solid composite	6,241	6,597	6,419
93-01363-A2		Solid composite	n/a	6,512	6,512
93-01371-A1	Core 49	Solid composite	95,889	71,503	83,696[QC:e]
Solids: fusion			μg/g	μg/g	μg/g
93-01355-H1	47: 1	Subsegment B	1.239E+05	1.393E+05	1.316E+05
93-01356-H1		Subsegment C	1.197E+05	1.209E+05	1.203E+05
93-01357-H1		Subsegment D	32,707	31,318	32,012.5
93-01360-H1	48: 1	Subsegment C	7,440	7,135	7,287.5
93-01361-H1		Subsegment D	9,600	10,061	9,830.5
93-01365-H1	49: 1	Subsegment B	1.811E+05	1.895E+05	1.853E+05
93-01366-H1		Subsegment C	97,539	94,009	95,774
93-01367-H1		Subsegment D	73,535	68,249	70,892

Table B2-18. Tank 241-C-109 Analytical Results: Aluminum (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (Continued)			**μg/g**	**μg/g**	**μg/g**
93-01367-H1T	49: 1 (Continued)	Subsegment D Upper half	61,744	62,999	62,371.5
93-01367-H1B		Subsegment D Lower half	53,141	55,933	54,537
93-01358-H1	Core 47	Solid composite	1.149E+05	1.187E+05	1.168E+05
93-01363-H1	Core 48	Solid composite	7,280	9,862	8,571[QC:e]
93-01371-H1	Core 49	Solid composite	1.195E+05	1.337E+05	1.266E+05
Solids: water digest			**μg/g**	**μg/g**	**μg/g**
93-01358-C1	Core 47	Solid composite	336	488	412[QC:e]
93-01363-C1	Core 48	Solid composite	115	104	109.5
93-01371-C1	Core 49	Solid composite	114	96	105
Drainable liquid: acid digest			**μg/g**	**μg/g**	**μg/g**
93-01354-A1	Tank composite	Liquid composite	161	153	157

Table B2-19. Tank 241-C-109 Analytical Results: Antimony (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	43	37	40
93-01361-A1B		Subsegment D Lower half	43	42	42.5
93-01367-A1T	49: 1	Subsegment D Upper half	70	54	62[QC:e]
93-01367-A1T		Subsegment D Upper half	25	42	33.5[QC:e]
93-01367-A1B		Subsegment D Lower half	37	42	39.5
93-01358-A1	Core 47	Solid composite	43	47	45
93-01363-A1	Core 48	Solid composite	46	67	56.5[QC:e]
93-01371-A1	Core 49	Solid composite	29	26	27.5

Table B2-20. Tank 241-C-109 Analytical Results: Barium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	46	42	44
93-01361-A1T		Subsegment D Upper half	45	43	44
93-01361-A1B		Subsegment D Lower half	52	47	49.5
93-01361-A1B		Subsegment D Lower half	50	47	48.5
93-01367-A1T	49: 1	Subsegment D Upper half	29	38	33.5[QC:e]
93-01367-A1T		Subsegment D Upper half	28	38	33[QC:e]
93-01367-A1B		Subsegment D Lower half	29	35	32
93-01367-A1B		Subsegment D Lower half	30	35	32.5
93-01358-A1	Core 47	Solid composite	59	n/a	59
93-01358-A1		Solid composite	56	58	57[QC:f]
93-01363-A1	Core 48	Solid composite	48	54	51
93-01363-A2		Solid composite	n/a	55	55
93-01371-A1	Core 49	Solid composite	32	24	28[QC:e,f]
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	84	100	92
93-01356-H1		Subsegment C	44	46	45
93-01357-H1		Subsegment D	77	79	78
93-01360-H1	48: 1	Subsegment C	84	75	79.5
93-01361-H1		Subsegment D	73	64	68.5

Table B2-20. Tank 241-C-109 Analytical Results: Barium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			μg/g	μg/g	μg/g
93-01365-H1	49: 1	Subsegment B	56	51	53.5
93-01366-H1		Subsegment C	42	39	40.5
93-01367-H1		Subsegment D	59	61	60
93-01367-H1T		Subsegment D Upper half	54	51	52.5
93-01367-H1B		Subsegment D Lower half	49	48	48.5
93-01358-H1	Core 47	Solid composite	82	79	80.5
93-01363-H1	Core 48	Solid composite	90	76	83
93-01371-H1	Core 49	Solid composite	41	41	41
Drainable liquid: acid digest			μg/g	μg/g	μg/g
93-01354-A1	Tank composite	Liquid composite	4	3	4[QC:d,e]

Table B2-21. Tank 241-C-109 Analytical Results: Boron (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			μg/g	μg/g	μg/g
93-01361-A1T	48: 1	Subsegment D Upper half	114	82	98[QC:e,f]
93-01361-A1T		Subsegment D Upper half	111	81	96[QC:e,f]
93-01361-A1B		Subsegment D Lower half	87	62	74.5[QC:e]
93-01361-A1B		Subsegment D Lower half	76	< 59	< 68

Table B2-21. Tank 241-C-109 Analytical Results: Boron (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			**µg/g**	**µg/g**	**µg/g**
93-01367-A1T	49: 1	Subsegment D Upper half	112	< 57	< 85[QC:f]
93-01367-A1T		Subsegment D Upper half	101	42	71.5[QC:c,f]
93-01367-A1B		Subsegment D Lower half	47	45	46
93-01358-A1	Core 47	Solid composite	161	n/a	161
93-01358-A1		Solid composite	146	108	127[QC:e,f]
93-01363-A1	Core 48	Solid composite	109	161	135[QC:e]
93-01363-A2		Solid composite	n/a	157	157
93-01371-A1	Core 49	Solid composite	65	46	55.5[QC:e,f]
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	18	21	19.5
93-01363-C1	Core 48	Solid composite	84	90	87
93-01371-C1	Core 49	Solid composite	21	23	22
Drainable liquid: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01354-A1	Tank composite	Liquid composite	93	40	67[QC:e]

Table B2-22. Tank 241-C-109 Analytical Results: Cadmium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01361-A1T	48: 1	Subsegment D Upper half	8	< 8	< 8
93-01361-A1T		Subsegment D Upper half	8	6	7[QC:e]
93-01361-A1B		Subsegment D Lower half	8	7	7.5
93-01361-A1B		Subsegment D Lower half	8	< 7	< 8
93-01367-A1T	49: 1	Subsegment D Upper half	< 7	8	< 8
93-01367-A1T		Subsegment D Upper half	5	7	6[QC:e]
93-01367-A1B		Subsegment D Lower half	6	7	6.5
93-01358-A1	Core 47	Solid composite	20	n/a	20
93-01358-A1		Solid composite	13	11	12
93-01363-A1	Core 48	Solid composite	7	10	8.5[QC:e]
93-01371-A1	Core 49	Solid composite	9	7	8[QC:e]

Table B2-23. Tank 241-C-109 Analytical Results: Calcium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	17,072	15,230	16,151
93-01361-A1T		Subsegment D Upper half	15,260	14,193	14,726.5
93-01361-A1B		Subsegment D Lower half	17,274	15,626	16,450
93-01361-A1B		Subsegment D Lower half	18,552	17,192	17,872
93-01367-A1T	49: 1	Subsegment D Upper half	15,951	21,496	18,723.5[QC:e]
93-01367-A1T		Subsegment D Upper half	14,646	19,372	17,009[QC:e]
93-01367-A1B		Subsegment D Lower half	16,856	18,738	17,797
93-01367-A1B		Subsegment D Lower half	18,470	21,051	19,760.5
93-01358-A1	Core 47	Solid composite	21,991	n/a	21,991[QC:f]
93-01358-A1		Solid composite	19,503	20,541	20,022[QC:e,f]
93-01363-A1	Core 48	Solid composite	14,376	10,734	12,555[QC:e]
93-01363-A2		Solid composite	n/a	11,407	11,407
93-01371-A1	Core 49	Solid composite	13,845	10,828	12,336.5[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	10,681	10,214	10,447.5[QC:f]
93-01356-H1		Subsegment C	18,359	17,736	18,047.5[QC:f]
93-01357-H1		Subsegment D	28,779	27,187	27,983[QC:f]
93-01360-H1	48: 1	Subsegment C	30,182	28,380	29,281[QC:f]
93-01361-H1		Subsegment D	16,961	16,603	16,782[QC:f]

Table B2-23. Tank 241-C-109 Analytical Results: Calcium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			**µg/g**	**µg/g**	**µg/g**
93-01365-H1	49: 1	Subsegment B	5,404	3,215	4,309.5[QC:e,f]
93-01366-H1		Subsegment C	18,864	18,248	18,556[QC:f]
93-01367-H1		Subsegment D	21,336	23,694	22,515[QC:f]
93-01367-H1T		Subsegment D Upper half	21,659	22,196	21,927.5[QC:f]
93-01367-H1B		Subsegment D Lower half	21,443	21,741	21,592[QC:f]
93-01358-H1	Core 47	Solid composite	24,409	24,911	24,660[QC:f]
93-01363-H1	Core 48	Solid composite	16,782	18,525	17,653.5[QC:f]
93-01371-H1	Core 49	Solid composite	14,476	15,245	14,860.5[QC:f]
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	173	194	183.5[QC:f]
93-01363-C1	Core 48	Solid composite	59	60	59.5
93-01371-C1	Core 49	Solid composite	89	66	77.5[QC:e]
Drainable liquid: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01354-A1	Tank composite	Liquid composite	213	205	209[QC:d,f]

Table B2-24. Tank 241-C-109 Analytical Results: Cerium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01358-A1	Core 47	Solid composite	273	n/a	273
93-01358-A1		Solid composite	75	78	76.5
93-01363-A1	Core 48	Solid composite	n/a	34	34
93-01371-A1	Core 49	Solid composite	46	26	36[QC:e]

Table B2-25. Tank 241-C-109 Analytical Results: Chromium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	227	196	211.5
93-01361-A1T		Subsegment D Upper half	218	194	206
93-01361-A1B		Subsegment D Lower half	241	224	232.5
93-01361-A1B		Subsegment D Lower half	239	229	234
93-01367-A1T	49: 1	Subsegment D Upper half	174	223	198.5[QC:e]
93-01367-A1T		Subsegment D Upper half	168	219	193.5[QC:e]
93-01367-A1B		Subsegment D Lower half	190	207	198.5
93-01367-A1B		Subsegment D Lower half	196	216	206

Table B2-25. Tank 241-C-109 Analytical Results: Chromium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			µg/g	µg/g	µg/g
93-01358-A1	Core 47	Solid composite	226	n/a	226
93-01358-A1		Solid composite	216	229	222.5
93-01363-A1	Core 48	Solid composite	212	208	210[QC:e]
93-01363-A2		Solid composite	n/a	210	210
93-01371-A1	Core 49	Solid composite	202	162	182[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	204	211	207.5
93-01356-H1		Subsegment C	242	217	229.5
93-01357-H1		Subsegment D	300	265	282.5
93-01360-H1	48: 1	Subsegment C	478	312	395[QC:e]
93-01361-H1		Subsegment D	309	252	280.5[QC:e]
93-01365-H1	49: 1	Subsegment B	147	139	143
93-01366-H1		Subsegment C	207	230	218.5
93-01367-H1		Subsegment D	244	273	258.5
93-01367-H1T		Subsegment D Upper half	255	263	259
93-01367-H1B		Subsegment D Lower half	241	248	244.5
93-01358-H1	Core 47	Solid composite	273	274	273.5
93-01363-H1	Core 48	Solid composite	268	251	259.5
93-01371-H1	Core 49	Solid composite	215	218	216.5

Table B2-25. Tank 241-C-109 Analytical Results: Chromium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	173	176	174.5
93-01363-C1	Core 48	Solid composite	217	234	225.5
93-01371-C1	Core 49	Solid composite	169	183	176
Drainable liquid: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01354-A1	Tank composite	Liquid composite	289	293	291[QC:d,f]

Table B2-26. Tank 241-C-109 Analytical Results: Cobalt (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01358-A1	Core 47	Solid composite	59	50	54.5
93-01371-A1	Core 49	Solid composite	71	37	54[QC:e]

Table B2-27. Tank 241-C-109 Analytical Results: Copper (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	10	< 9	< 10
93-01361-A1T		Subsegment D Upper half	14	12	13
93-01361-A1B		Subsegment D Lower half	14	14	14
93-01367-A1T	49: 1	Subsegment D Upper half	12	14	13
93-01367-A1T		Subsegment D Upper half	14	15	14.5
93-01367-A1B		Subsegment D Lower half	13	17	15[QC:e]
93-01367-A1B		Subsegment D Lower half	12	14	13
93-01358-A1	Core 47	Solid composite	62	n/a	62
93-01358-A1		Solid composite	65	54	59.5
93-01363-A1	Core 48	Solid composite	14	28	21[QC:e]
93-01363-A2		Solid composite	n/a	23	23
93-01371-A1	Core 49	Solid composite	25	24	24.5
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	199	205	202[QC:f]
93-01356-H1		Subsegment C	124	136	130[QC:f]
93-01357-H1		Subsegment D	81	38	59.5[QC:e,f]
93-01360-H1	48: 1	Subsegment C	152	36	94[QC:e,f]
93-01361-H1		Subsegment D	231	49	140[QC:e,f]

Table B2-27. Tank 241-C-109 Analytical Results: Copper (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			µg/g	µg/g	µg/g
93-01365-H1	49: 1	Subsegment B	178	208	193[QC:f]
93-01366-H1		Subsegment C	59	164	111.5[QC:e,f]
93-01367-H1		Subsegment D	63	128	95.5[QC:e]
93-01367-H1T		Subsegment D Upper half	58	154	106[QC:e]
93-01367-H1B		Subsegment D Lower half	56	48	52
93-01358-H1	Core 47	Solid composite	80	90	85
93-01363-H1	Core 48	Solid composite	50	43	46.5
93-01371-H1	Core 49	Solid composite	61	53	57

Table B2-28. Tank 241-C-109 Analytical Results: Dysprosium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01358-A1	Core 47	Solid composite	15	n/a	15
93-01358-A1		Solid composite	2	2	2
93-01363-A1	Core 48	Solid composite	1	3	2[QC:e]
93-01363-A2		Solid composite	n/a	16	16

Table B2-29. Tank 241-C-109 Analytical Results: Iron (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01361-A1T	48: 1	Subsegment D Upper half	24,893	13,727	19,310[QC:e]
93-01361-A1T		Subsegment D Upper half	23,845	13,747	18,796[QC:e]
93-01361-A1B		Subsegment D Lower half	17,755	16,752	17,253.5
93-01361-A1B		Subsegment D Lower half	17,652	17,088	17,370
93-01367-A1T	49: 1	Subsegment D Upper half	8,981	11,703	10,342[QC:e]
93-01367-A1T		Subsegment D Upper half	8,846	11,532	10,189[QC:e]
93-01367-A1B		Subsegment D Lower half	9,050	11,175	10,112.5[QC:e]
93-01367-A1B		Subsegment D Lower half	9,195	11,544	10,369.5[QC:e]
93-01358-A1	Core 47	Solid composite	36,514	n/a	36514
93-01358-A1		Solid composite	35,176	22,385	28,780.5[QC:c,e,f]
93-01363-A1	Core 48	Solid composite	13,929	26,461	20,195[QC:e]
93-01363-A2		Solid composite	n/a	26,521	26,521
93-01371-A1	Core 49	Solid composite	8,393	5,899	7,146[QC:e]
Solids: fusion			**µg/g**	**µg/g**	**µg/g**
93-01355-H1	47: 1	Subsegment B	82,536	44,184	63,360[QC:e,f]
93-01356-H1		Subsegment C	15,380	26,502	20,941[QC:e,f]
93-01357-H1		Subsegment D	17,085	13,521	15,303[QC:e,f]
93-01360-H1	48: 1	Subsegment C	22,752	17,233	19,992.5[QC:f]
93-01361-H1		Subsegment D	22,697	19,379	21,038[QC:f]

Table B2-29. Tank 241-C-109 Analytical Results: Iron (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			**$\mu g/g$**	**$\mu g/g$**	**$\mu g/g$**
93-01365-H1	49: 1	Subsegment B	13,783	17,371	15,577[QC:e,f]
93-01366-H1		Subsegment C	4,333	4,816	4,574.5[QC:f]
93-01367-H1		Subsegment D	13,611	17,210	15,410.5[QC:e,f]
93-01367-H1T		Subsegment D Upper half	13,714	14,447	14,080.5[QC:f]
93-01367-H1B		Subsegment D Lower half	12,753	12,811	12,782[QC:f]
93-01358-H1	Core 47	Solid composite	20,231	23,379	21,805[QC:f]
93-01363-H1	Core 48	Solid composite	23,818	20,614	22,216[QC:f]
93-01371-H1	Core 49	Solid composite	9,267	8,938	9,102.5[QC:f]
Solids: water digest			**$\mu g/g$**	**$\mu g/g$**	**$\mu g/g$**
93-01358-C1	Core 47	Solid composite	885	872	878.5
93-01363-C1	Core 48	Solid composite	1,128	1,149	1,138.5
93-01371-C1	Core 49	Solid composite	888	944	916
Drainable liquid: acid digest			**$\mu g/g$**	**$\mu g/g$**	**$\mu g/g$**
93-01354-A1	Tank composite	Liquid composite	1,650	1,700	1,670[QC:d]

Table B2-30. Tank 241-C-109 Analytical Results: Lanthanum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			μg/g	μg/g	μg/g
93-01361-A1T	48: 1	Subsegment D Upper half	7	5	6[QC:e]
93-01361-A1B		Subsegment D Lower half	9	7	8[QC:e]
93-01367-A1T	49: 1	Subsegment D Upper half	13	14	13.5
93-01367-A1T		Subsegment D Upper half	9	10	9.5
93-01367-A1B		Subsegment D Lower half	7	9	8[QC:e]
93-01367-A1B		Subsegment D Lower half	13	< 12	< 13
93-01358-A1	Core 47	Solid composite	93	n/a	93
93-01358-A1		Solid composite	81	81	81
93-01363-A1	Core 48	Solid composite	6	7	6.5
93-01371-A1	Core 49	Solid composite	51	38	44.5[QC:e]
Solids: fusion			μg/g	μg/g	μg/g
93-01355-H1	47: 1	Subsegment B	111	121	116
93-01356-H1		Subsegment C	35	< 40	< 38
93-01365-H1	49: 1	Subsegment B	100	72	86[QC:e]

Table B2-31. Tank 241-C-109 Analytical Results: Lead (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	651	584	617.5
93-01361-A1T		Subsegment D Upper half	617	568	592.5
93-01361-A1B		Subsegment D Lower half	723	645	684
93-01361-A1B		Subsegment D Lower half	725	665	695
93-01367-A1T	49: 1	Subsegment D Upper half	504	682	593[QC:e]
93-01367-A1T		Subsegment D Upper half	485	670	577.5[QC:e]
93-01367-A1B		Subsegment D Lower half	508	616	562
93-01367-A1B		Subsegment D Lower half	508	628	568[QC:e]
93-01358-A1	Core 47	Solid composite	10,504	n/a	10,504
93-01358-A1		Solid composite	9,959	7,252	8,605.5[QC:c,e]
93-01363-A1	Core 48	Solid composite	586	626	606
93-01363-A2		Solid composite	n/a	627	627
93-01371-A1	Core 49	Solid composite	999	728	863.5[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	5,530	4,568	5,049
93-01356-H1		Subsegment C	2,985	2,779	2,882
93-01357-H1		Subsegment D	18,572	10,014	14,293[QC:e]
93-01360-H1	48: 1	Subsegment C	635	473	554[QC:e]
93-01361-H1		Subsegment D	724	662	693

Table B2-31. Tank 241-C-109 Analytical Results: Lead (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			$\mu g/g$	$\mu g/g$	$\mu g/g$
93-01365-H1	49: 1	Subsegment B	2,074	1,900	1,987
93-01366-H1		Subsegment C	407	335	371
93-01367-H1		Subsegment D	695	762	728.5
93-01367-H1T		Subsegment D Upper half	625	745	685
93-01367-H1B		Subsegment D Lower half	646	650	648
93-01358-H1	Core 47	Solid composite	7,221	7,336	7,278.5
93-01363-H1	Core 48	Solid composite	748	656	702
93-01371-H1	Core 49	Solid composite	803	844	823.5
Solids: water digest			$\mu g/g$	$\mu g/g$	$\mu g/g$
93-01358-C1	Core 47	Solid composite	41	55	48[QC:e]

Table B2-32. Tank 241-C-109 Analytical Results: Lithium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	8	11	9.5[QC:e]
93-01361-A1T		Subsegment D Upper half	5	5	5
93-01361-A1B		Subsegment D Lower half	7	6	6.5
93-01367-A1T	49: 1	Subsegment D Upper half	10	9	9.5
93-01367-A1T		Subsegment D Upper half	3	4	3.5[QC:e]
93-01367-A1B		Subsegment D Lower half	4	5	4.5[QC:e]
93-01367-A1B		Subsegment D Lower half	9	8	8.5
93-01358-A1	Core 47	Solid composite	18	n/a	18
93-01358-A1		Solid composite	4	4	4
93-01363-A1	Core 48	Solid composite	9	9	9
93-01363-A2		Solid composite	n/a	22	22
93-01371-A1	Core 49	Solid composite	3	2	2.5[QC:e]

Table B2-33. Tank 241-C-109 Analytical Results: Magnesium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	634	564	599[QC:f]
93-01361-A1T		Subsegment D Upper half	586	539	562.5[QC:f]
93-01361-A1B		Subsegment D Lower half	651	591	621
93-01361-A1B		Subsegment D Lower half	666	627	646.5
93-01367-A1T	49: 1	Subsegment D Upper half	405	523	464[QC:e,f]
93-01367-A1T		Subsegment D Upper half	389	494	441.5[QC:e,f]
93-01367-A1B		Subsegment D Lower half	417	467	442
93-01367-A1B		Subsegment D Lower half	443	504	473.5
93-01358-A1	Core 47	Solid composite	481	n/a	481
93-01358-A1		Solid composite	444	493	468.5[QC:f]
93-01363-A1	Core 48	Solid composite	527	497	512
93-01363-A2		Solid composite	n/a	521	521
93-01371-A1	Core 49	Solid composite	325	267	296[QC:f]
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	1,200	615	907.5[QC:e,f]
93-01356-H1		Subsegment C	363	365	364[QC:f]
93-01357-H1		Subsegment D	545	577	561[QC:f]
93-01360-H1	48: 1	Subsegment C	732	672	702[QC:f]
93-01361-H1		Subsegment D	590	574	582[QC:f]

Table B2-33. Tank 241-C-109 Analytical Results: Magnesium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			**µg/g**	**µg/g**	**µg/g**
93-01365-H1	49: 1	Subsegment B	213	158	185.5[QC:e,f]
93-01366-H1		Subsegment C	294	284	289[QC:f]
93-01367-H1		Subsegment D	469	526	497.5[QC:f]
93-01367-H1T		Subsegment D Upper half	471	486	478.5[QC:f]
93-01367-H1B		Subsegment D Lower half	454	465	459.5[QC:f]
93-01358-H1	Core 47	Solid composite	668	626	647[QC:f]
93-01363-H1	Core 48	Solid composite	681	649	665[QC:f]
93-01371-H1	Core 49	Solid composite	334	347	340.5[QC:f]
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	8	8	8[QC:f]
93-01363-C1	Core 48	Solid composite	7	7	7
93-01371-C1	Core 49	Solid composite	6	6	6
Drainable liquid: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01354-A1	Tank composite	Liquid composite	26	26	26[QC:f]

Table B2-34. Tank 241-C-109 Analytical Results: Manganese (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	107	60	83.5[QC:e]
93-01361-A1T		Subsegment D Upper half	102	60	81[QC:e]
93-01361-A1B		Subsegment D Lower half	78	74	76
93-01361-A1B		Subsegment D Lower half	79	76	77.5
93-01367-A1T	49: 1	Subsegment D Upper half	50	61	55.5
93-01367-A1T		Subsegment D Upper half	48	60	54[QC:e]
93-01367-A1B		Subsegment D Lower half	47	58	52.5[QC:e]
93-01367-A1B		Subsegment D Lower half	48	60	54[QC:e]
93-01358-A1	Core 47	Solid composite	167	n/a	167
93-01358-A1		Solid composite	162	106	134[QC:c,e]
93-01363-A1	Core 48	Solid composite	54	138	96[QC:c,e]
93-01363-A2		Solid composite	n/a	138	138
93-01371-A1	Core 49	Solid composite	57	39	48[QC:e]

Table B2-34. Tank 241-C-109 Analytical Results: Manganese (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μg/g	μg/g	μg/g
93-01355-H1	47: 1	Subsegment B	505	425	465[QC:f]
93-01356-H1		Subsegment C	197	252	224.5[QC:e,f]
93-01357-H1		Subsegment D	371	207	289[QC:e,f]
93-01360-H1	48: 1	Subsegment C	238	274	256[QC:f]
93-01361-H1		Subsegment D	172	114	143[QC:e,f]
93-01365-H1	49: 1	Subsegment B	180	245	212.5[QC:e,f]
93-01366-H1		Subsegment C	139	181	160[QC:e,f]
93-01367-H1		Subsegment D	270	269	269.5[QC:f]
93-01367-H1T		Subsegment D Upper half	178	169	173.5[QC:f]
93-01367-H1B		Subsegment D Lower half	128	102	115[QC:e,f]
93-01358-H1	Core 47	Solid composite	149	172	160.5[QC:f]
93-01363-H1	Core 48	Solid composite	145	124	134.5[QC:f]
93-01371-H1	Core 49	Solid composite	93	82	87.5[QC:f]

Table B2-35. Tank 241-C-109 Analytical Results: Molybdenum (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	35	28	31.5QC:e
93-01361-A1T		Subsegment D Upper half	31	27	29
93-01361-A1B		Subsegment D Lower half	33	31	32
93-01361-A1B		Subsegment D Lower half	33	32	32.5
93-01367-A1T	49: 1	Subsegment D Upper half	34	43	38.5QC:e
93-01367-A1T		Subsegment D Upper half	30	38	34QC:e
93-01367-A1B		Subsegment D Lower half	32	36	34
93-01367-A1B		Subsegment D Lower half	35	41	38
93-01358-A1	Core 47	Solid composite	50	n/a	50
93-01358-A1		Solid composite	43	43	43
93-01363-A1	Core 48	Solid composite	31	31	31
93-01363-A2		Solid composite	n/a	33	33
93-01371-A1	Core 49	Solid composite	45	35	40QC:e
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	< 47	48	< 48
93-01356-H1		Subsegment C	41	43	42
93-01360-H1	48: 1	Subsegment C	37	< 40	< 39
93-01361-H1		Subsegment D	39	30	34.5QC:e

Table B2-35. Tank 241-C-109 Analytical Results: Molybdenum (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			**µg/g**	**µg/g**	**µg/g**
93-01365-H1	49: 1	Subsegment B	55	55	55
93-01366-H1		Subsegment C	38	38	38
93-01367-H1		Subsegment D	40	50	45[QC:e]
93-01367-H1T		Subsegment D Upper half	32	41	36.5[QC:e]
93-01371-H1	Core 49	Solid composite	35	37	36
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	24	25	24.5
93-01363-C1	Core 48	Solid composite	29	31	30
93-01371-C1	Core 49	Solid composite	22	25	23.5
Drainable liquid: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01354-A1	Tank composite	Liquid composite	40	40	40

Table B2-36. Tank 241-C-109 Analytical Results: Neodymium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01361-A1T	48: 1	Subsegment D Upper half	31	27	29
93-01361-A1B		Subsegment D Lower half	39	30	34.5[QC:e]
93-01367-A1T	49: 1	Subsegment D Upper half	53	73	63[QC:e]
93-01367-A1T		Subsegment D Upper half	22	43	32.5[QC:e]
93-01367-A1B		Subsegment D Lower half	35	42	38.5
93-01367-A1B		Subsegment D Lower half	58	64	61
93-01358-A1	Core 47	Solid composite	208	n/a	208
93-01358-A1		Solid composite	130	129	129.5
93-01363-A1	Core 48	Solid composite	43	45	44
93-01363-A2		Solid composite	n/a	130	130
93-01371-A1	Core 49	Solid composite	90	68	79[QC:e]
Solids: fusion			**µg/g**	**µg/g**	**µg/g**
93-01365-H1	49: 1	Subsegment B	123	< 112	< 117

Table B2-37. Tank 241-C-109 Analytical Results: Nickel (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01361-A1T	48: 1	Subsegment D Upper half	18,131	15,782	16,956.5
93-01361-A1T		Subsegment D Upper half	17,131	15,563	16,347
93-01361-A1B		Subsegment D Lower half	19,429	17,366	18,397.5
93-01361-A1B		Subsegment D Lower half	19,656	18,018	18,837
93-01367-A1T	49: 1	Subsegment D Upper half	12,285	16,158	14,221.5[QC:e]
93-01367-A1T		Subsegment D Upper half	11,875	15,601	13,738[QC:e]
93-01367-A1B		Subsegment D Lower half	12,912	14,838	13,875
93-01367-A1B		Subsegment D Lower half	13,399	15,651	14,525
93-01358-A1	Core 47	Solid composite	15,427	n/a	15,427
93-01358-A1		Solid composite	14,555	14,884	14,719.5
93-01363-A1	Core 48	Solid composite	16,307	14,732	15,519.5
93-01363-A2		Solid composite	n/a	15,073	15,073
93-01371-A1	Core 49	Solid composite	13,115	10,620	11,867.5[QC:e]
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	140	109	124.5[QC:e]

Table B2-37. Tank 241-C-109 Analytical Results: Nickel (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
93-01363-C1	Core 48	Solid composite	33	29	31
93-01371-C1	Core 49	Solid composite	53	53	53
Drainable liquid: acid digest			μg/g	μg/g	μg/g
93-01354-A1	Tank composite	Liquid composite	340	347	344[QC:d]

Table B2-38. Tank 241-C-109 Analytical Results: Phosphorus (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			μg/g	μg/g	μg/g
93-01361-A1T	48: 1	Subsegment D Upper half	28,242	31,015	29,628.5
93-01361-A1T		Subsegment D Upper half	26,887	30,819	28,853
93-01361-A1B		Subsegment D Lower half	19,570	22,926	21,248
93-01361-A1B		Subsegment D Lower half	19,858	23,634	21,746
93-01367-A1T	49: 1	Subsegment D Upper half	33,361	19,163	26,262[QC:e]
93-01367-A1T		Subsegment D Upper half	32,278	18,582	25,430[QC:e]
93-01367-A1B		Subsegment D Lower half	20,901	17,509	19,205
93-01367-A1B		Subsegment D Lower half	21,775	18,217	19,996
93-01358-A1	Core 47	Solid composite	19,039	n/a	19,039
93-01358-A1		Solid composite	18,434	18,447	18,440.5

Table B2-38. Tank 241-C-109 Analytical Results: Phosphorus (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
93-01363-A1	Core 48	Solid composite	14,487	19,591	17,039QC:e
93-01363-A2		Solid composite	n/a	19,591	19,591
Solids: acid digest (continued)			**µg/g**	**µg/g**	**µg/g**
93-01371-A1	Core 49	Solid composite	11,710	27,108	19,409QC:e
Solids: fusion			**µg/g**	**µg/g**	**µg/g**
93-01355-H1	47: 1	Subsegment B	7,366	7,889	7,627.5
93-01356-H1		Subsegment C	12,566	12,336	12,451
93-01357-H1		Subsegment D	29,014	31,182	30,098
93-01360-H1	48: 1	Subsegment C	26,246	20,259	23,252.5QC:e
93-01361-H1		Subsegment D	20,244	21,630	20,937
93-01365-H1	49: 1	Subsegment B	4,572	3,649	4,110.5QC:e
93-01366-H1		Subsegment C	11,370	11,580	11,475
93-01367-H1		Subsegment D	20,473	20,315	20,394
93-01367-H1T		Subsegment D Upper half	18,653	19,072	18,862.5
93-01367-H1B		Subsegment D Lower half	19,539	18,624	19,081.5
93-01358-H1	Core 47	Solid composite	20,152	19,586	19,869
93-01363-H1	Core 48	Solid composite	22,210	18,154	20,182QC:e
93-01371-H1	Core 49	Solid composite	17,745	11,435	14,590QC:e
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	6,349	7,629	6,989
93-01363-C1	Core 48	Solid composite	11,918	5,461	8,689.5QC:e

Table B2-38. Tank 241-C-109 Analytical Results: Phosphorus (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
93-01371-C1	Core 49	Solid composite	4,422	3,900	4,161
Drainable liquid: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01354-A1	Tank composite	Liquid composite	4,170	4,230	4,200

Table B2-39. Tank 241-C-109 Analytical Results: Potassium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01361-A1T	48: 1	Subsegment D Upper half	571	393	482[QC:e]
93-01361-A1T		Subsegment D Upper half	648	527	587.5[QC:e]
93-01361-A1B		Subsegment D Lower half	649	614	631.5
93-01361-A1B		Subsegment D Lower half	416	391	403.5
93-01367-A1T	49: 1	Subsegment D Upper half	378	560	469[QC:e]
93-01367-A1T		Subsegment D Upper half	367	525	446[QC:e]
93-01367-A1B		Subsegment D Lower half	450	518	484
93-01367-A1B		Subsegment D Lower half	463	389	426
93-01358-A1	Core 47	Solid composite	954	n/a	954
93-01358-A1		Solid composite	581	593	587
93-01363-A1	Core 48	Solid composite	609	665	637
93-01363-A2		Solid composite	n/a	1046	1046

Table B2-39. Tank 241-C-109 Analytical Results: Potassium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
93-01371-A1	Core 49	Solid composite	460	354	407[QC:e]
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	510	558	534
93-01363-C1	Core 48	Solid composite	540	576	558
93-01371-C1	Core 49	Solid composite	428	468	448
Drainable liquid: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01354-A1	Tank composite	Liquid composite	835	844	840[QC:d]

Table B2-40. Tank 241-C-109 Analytical Results: Rhenium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01361-A1T	48: 1	Subsegment D Upper half	5	5	5
93-01361-A1B		Subsegment D Lower half	6	6	6
93-01367-A1T	49: 1	Subsegment D Upper half	5	9	7[QC:e]
93-01367-A1B		Subsegment D Lower half	7	9	8[QC:e]
93-01358-A1	Core 47	Solid composite	10	9	9.5
93-01363-A1	Core 48	Solid composite	6	6	6
93-01371-A1	Core 49	Solid composite	8	5	6.5[QC:e]

Table B2-41. Tank 241-C-109 Analytical Results: Ruthenium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			μg/g	μg/g	μg/g
93-01363-A1	Core 48	Solid composite	n/a	11	11

Table B2-42. Tank 241-C-109 Analytical Results: Silicon (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			μg/g	μg/g	μg/g
93-01361-A1T	48: 1	Subsegment D Upper half	822	816	819
93-01361-A1T		Subsegment D Upper half	912	984	948
93-01361-A1B		Subsegment D Lower half	1,290	974	1,132[QC:e]
93-01361-A1B		Subsegment D Lower half	1,164	866	1,015[QC:e]
93-01367-A1T	49: 1	Subsegment D Upper half	649	685	667
93-01367-A1T		Subsegment D Upper half	716	710	713[QC:f]
93-01367-A1B		Subsegment D Lower half	623	726	674.5
93-01367-A1B		Subsegment D Lower half	569	686	627.5
93-01358-A1	Core 47	Solid composite	1,701	n/a	1,701
93-01358-A1		Solid composite	1,659	2,148	1,903.5[QC:c,e,f]

Table B2-42. Tank 241-C-109 Analytical Results: Silicon (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			**µg/g**	**µg/g**	**µg/g**
93-01363-A1	Core 48	Solid composite	1,229	1,394	1,311.5
93-01363-A2		Solid composite	n/a	1,174	1,174
93-01371-A1	Core 49	Solid composite	1,515	1,272	1,393.5[QC:f]
Solids: fusion			**µg/g**	**µg/g**	**µg/g**
93-01355-H1	47: 1	Subsegment B	18,466	18,968	18,717
93-01356-H1		Subsegment C	6,032	6,183	6,107.5
93-01357-H1		Subsegment D	23,867	20,566	22,216.5
93-01360-H1	48: 1	Subsegment C	3,420	2,350	2,885[QC:e]
93-01361-H1		Subsegment D	2,531	1,899	2,215[QC:e]
93-01365-H1	49: 1	Subsegment B	3,075	2,717	2,896
93-01366-H1		Subsegment C	832	935	883.5
93-01367-H1		Subsegment D	1,461	1,908	1,684.5[QC:e]
93-01367-H1T		Subsegment D Upper half	1,257	1,477	1,367
93-01367-H1B		Subsegment D Lower half	1,176	1,229	1,202.5
93-01358-H1	Core 47	Solid composite	16,787	14,738	15,762.5[QC:f]
93-01363-H1	Core 48	Solid composite	2,078	2,256	2,167[QC:f]
93-01371-H1	Core 49	Solid composite	2,244	2,372	2,308[QC:f]
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	112	122	117
93-01363-C1	Core 48	Solid composite	303	91	197[QC:e]
93-01371-C1	Core 49	Solid composite	65	75	70

Table B2-42. Tank 241-C-109 Analytical Results: Silicon (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid: acid digest			µg/g	µg/g	µg/g
93-01354-A1	Tank composite	Liquid composite	74	63	69[QC:d]

Table B2-43. Tank 241-C-109 Analytical Results: Sodium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	1.201E+05	1.206E+05	1.204E+05
93-01361-A1T		Subsegment D Upper half	1.160E+05	1.213E+05	1.187E+05
93-01361-A1B		Subsegment D Lower half	99,304	1.064E+05	1.029E+05
93-01361-A1B		Subsegment D Lower half	98,269	1.081E+05	1.032E+05
93-01367-A1T	49: 1	Subsegment D Upper half	1.167E+05	86,879	1.018E+05[QC:e]
93-01367-A1T		Subsegment D Upper half	1.158E+05	86,588	1.012E+05[QC:e]
93-01367-A1B		Subsegment D Lower half	87,982	80,067	84,024.5
93-01367-A1B		Subsegment D Lower half	88,699	81,975	85,337
93-01358-A1	Core 47	Solid composite	82,155	n/a	82,155
93-01358-A1		Solid composite	81,535	82,178	81,856.5

Table B2-43. Tank 241-C-109 Analytical Results: Sodium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			**µg/g**	**µg/g**	**µg/g**
93-01363-A1	Core 48	Solid composite	81,622	93,517	87,569.5
93-01363-A2		Solid composite	n/a	92,587	92,587
93-01371-A1	Core 49	Solid composite	65,806	96,785	81,295.5[QC:e]
Solids: fusion			**µg/g**	**µg/g**	**µg/g**
93-01355-H1	47: 1	Subsegment B	49,692	52,421	51,056.5[QC:f]
93-01356-H1		Subsegment C	63,188	62,933	63,060.5[QC:f]
93-01357-H1		Subsegment D	1.017E+05	1.036E+05	1.026E+05[QC:f]
93-01360-H1	48: 1	Subsegment C	1.383E+05	93,344	1.158E+05[QC:e,f]
93-01361-H1		Subsegment D	1.011E+05	1.029E+05	1.020E+05[QC:f]
93-01365-H1	49: 1	Subsegment B	45,066	40,977	43,021.5[QC:f]
93-01366-H1		Subsegment C	60,864	64,841	62,852.5[QC:f]
93-01367-H1		Subsegment D	90,234	92,536	91,385[QC:f]
93-01367-H1T		Subsegment D Upper half	90,812	90,543	90,677.5[QC:f]
93-01367-H1B		Subsegment D Lower half	90,231	89,172	89,701.5[QC:f]
93-01358-H1	Core 47	Solid composite	87,144	87,158	87,151[QC:f]
93-01363-H1	Core 48	Solid composite	1.06E+05	93,250	1.001E+05[QC:f]
93-01371-H1	Core 49	Solid composite	81,785	71,262	76,523.5[QC:f]
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	66,028	69,553	67,790.5
93-01363-C1	Core 48	Solid composite	89,161	77,859	83,510

Table B2-43. Tank 241-C-109 Analytical Results: Sodium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid: acid digest			µg/g	µg/g	µg/g
93-01354-A1	Tank composite	Liquid composite	96,950	96,940	96,950
93-01371-C1	Core 49	Solid composite	58,920	60,875	59,897.5

Table B2-44. Tank 241-C-109 Analytical Results: Strontium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	443	405	424
93-01361-A1T		Subsegment D Upper half	431	410	420.5
93-01361-A1B		Subsegment D Lower half	501	450	475.5
93-01361-A1B		Subsegment D Lower half	493	454	473.5
93-01367-A1T	49: 1	Subsegment D Upper half	299	406	352.5[QC:e]
93-01367-A1T		Subsegment D Upper half	297	406	351.5[QC:e]
93-01367-A1B		Subsegment D Lower half	312	369	340.5
93-01367-A1B		Subsegment D Lower half	313	377	345
93-01358-A1	Core 47	Solid composite	190	n/a	190
93-01358-A1		Solid composite	188	190	189

Table B2-44. Tank 241-C-109 Analytical Results: Strontium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			**µg/g**	**µg/g**	**µg/g**
93-01363-A1	Core 48	Solid composite	397	492	444.5[QC:e]
93-01363-A2		Solid composite	n/a	486	486
93-01371-A1	Core 49	Solid composite	167	142	154.5
Solids: fusion			**µg/g**	**µg/g**	**µg/g**
93-01355-H1	47: 1	Subsegment B	169	166	167.5
93-01356-H1		Subsegment C	143	138	140.5
93-01357-H1		Subsegment D	203	189	196
93-01360-H1	48: 1	Subsegment C	657	548	602.5
93-01361-H1		Subsegment D	466	459	462.5
93-01365-H1	49: 1	Subsegment B	111	93	102
93-01366-H1		Subsegment C	79	75	77
93-01367-H1		Subsegment D	404	453	428.5
93-01367-H1T		Subsegment D Upper half	409	412	410.5
93-01367-H1B		Subsegment D Lower half	363	384	373.5
93-01358-H1	Core 47	Solid composite	204	203	203.5
93-01363-H1	Core 48	Solid composite	831	689	760
93-01371-H1	Core 49	Solid composite	167	170	168.5
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01358-C1	Core 47	Solid composite	1	1	1
93-01363-C1	Core 48	Solid composite	1	1	1
93-01371-C1	Core 49	Solid composite	1	0.00	< 0.8[QC:e]

Table B2-44. Tank 241-C-109 Analytical Results: Strontium (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid: acid digest			µg/g	µg/g	µg/g
93-01354-A1	Tank composite	Liquid composite	0.00	1	< 0.8

Table B2-45. Tank 241-C-109 Analytical Results: Tellurium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01367-A1T	49: 1	Subsegment D Upper half	35	44	39.5[QC:c]
93-01367-A1B		Subsegment D Lower half	39	46	42.5
93-01358-A1	Core 47	Solid composite	72	71	71.5
93-01371-A1	Core 49	Solid composite	93	69	81[QC:c]

Table B2-46. Tank 241-C-109 Analytical Results: Thorium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01358-A1	Core 47	Solid composite	234	n/a	234
93-01358-A1		Solid composite	68	71	69.5
93-01363-A1	Core 48	Solid composite	30	49	39.5[QC:e]
93-01363-A2		Solid composite	n/a	229	229
93-01371-A1	Core 49	Solid composite	37	16	26.5[QC:e]

Table B2-47. Tank 241-C-109 Analytical Results: Titanium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	< 5	6	< 6
93-01361-A1T		Subsegment D Upper half	7	6	6.5
93-01361-A1B		Subsegment D Lower half	7	7	7
93-01367-A1T	49: 1	Subsegment D Upper half	6	7	6.5
93-01367-A1T		Subsegment D Upper half	3	4	3.5[QC:e]
93-01367-A1B		Subsegment D Lower half	3	3	3
93-01367-A1B		Subsegment D Lower half	6	< 5	< 6

Table B2-47. Tank 241-C-109 Analytical Results: Titanium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			**μg/g**	**μg/g**	**μg/g**
93-01358-A1	Core 47	Solid composite	63	n/a	63
93-01358-A1		Solid composite	55	64	59.5
93-01363-A1	Core 48	Solid composite	8	13	10.5[QC:e]
93-01371-A1	Core 49	Solid composite	7	4	5.5[QC:e]
Solids: fusion			**μg/g**	**μg/g**	**μg/g**
93-01355-H1	47: 1	Subsegment B	424	392	408
93-01356-H1		Subsegment C	101	116	108.5
93-01357-H1		Subsegment D	166	224	195[QC:e]
93-01360-H1	48: 1	Subsegment C	< 12	69	< 41
93-01361-H1		Subsegment D	31	24	27.5[QC:e]
93-01365-H1	49: 1	Subsegment B	84	46	65[QC:e]
93-01367-H1		Subsegment D	12	17	14.5[QC:e]
93-01358-H1	Core 47	Solid composite	385	216	300.5[QC:e]
93-01363-H1	Core 48	Solid composite	17	< 15	< 16
93-01371-H1	Core 49	Solid composite	< 13	13	< 13

Table B2-48. Tank 241-C-109 Analytical Results: Total Uranium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µg/g**	**µg/g**	**µg/g**
93-01361-A1T	48: 1	Subsegment D Upper half	15,802	14,448	15,125
93-01361-A1T		Subsegment D Upper half	15,389	14,508	14,948.5
93-01361-A1B		Subsegment D Lower half	17,409	15,510	16,459.5
93-01361-A1B		Subsegment D Lower half	16,770	15,256	16,013
93-01367-A1T	49: 1	Subsegment D Upper half	9,984	13,517	11,750.5[QC:e]
93-01367-A1T		Subsegment D Upper half	9,708	13,416	11,562[QC:e]
93-01367-A1B		Subsegment D Lower half	10,027	12,114	11,070.5
93-01367-A1B		Subsegment D Lower half	10,317	12,262	11,289.5
93-01358-A1	Core 47	Solid composite	11,643	n/a	11,643
93-01358-A1		Solid composite	10,454	10,955	10,704.5
93-01363-A1	Core 48	Solid composite	12,684	17,377	15,030.5[QC:e]
93-01363-A2		Solid composite	n/a	18,147	18,147
93-01371-A1	Core 49	Solid composite	7,102	5,429	6,265.5[QC:d,e]
Solids: fusion			**µg/g**	**µg/g**	**µg/g**
93-01355-H1	47: 1	Subsegment B	11,529	12,032	11,780.5
93-01356-H1		Subsegment C	6,615	5,680	6,147.5
93-01357-H1		Subsegment D	6,244	5,441	5,842.5
93-01357-H1	48: 1	Subsegment C	18,058	15,381	16,719.5
93-01361-H1		Subsegment D	14,622	14,101	14,361.5

Table B2-48. Tank 241-C-109 Analytical Results: Total Uranium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			**μg/g**	**μg/g**	**μg/g**
93-01365-H1	49: 1	Subsegment B	8,656	7,146	7,901
93-01366-H1		Subsegment C	1,169	1,432	1,300.5[QC:e]
93-01367-H1		Subsegment D	11,547	13,238	12,392.5
93-01367-H1T		Subsegment D Upper half	12,251	13,080	12,665.5
93-01367-H1B		Subsegment D Lower half	10,829	11,783	11,306
93-01358-H1	Core 47	Solid composite	8,745	9,609	9,177
93-01363-H1	Core 48	Solid composite	27,793	21,698	24,745.5[QC:e]
93-01371-H1	Core 49	Solid composite	5,588	3,894	4,741[QC:e]
Solids: water digest			**μg/g**	**μg/g**	**μg/g**
93-01358-C1	Core 47	Solid composite	< 138	156	< 147

Table B2-49. Tank 241-C-109 Analytical Results: Vanadium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**μg/g**	**μg/g**	**μg/g**
93-01361-A1T	48: 1	Subsegment D Upper half	3	2	2.5[QC:e]
93-01361-A1B		Subsegment D Lower half	2	2	2
93-01367-A1T	49: 1	Subsegment D Upper half	4	4	4
93-01367-A1B		Subsegment D Lower half	3	4	3.5[QC:e]

Table B2-49. Tank 241-C-109 Analytical Results: Vanadium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			µg/g	µg/g	µg/g
93-01358-A1	Core 47	Solid composite	21	n/a	21
93-01358-A1		Solid composite	15	13	14
93-01363-A1	Core 48	Solid composite	4	9	6.5[QC:e]
93-01371-A1	Core 49	Solid composite	6	4	5[QC:e]
Solids: water digest			µg/g	µg/g	µg/g
93-01358-C1	Core 47	Solid composite	< 2	2	< 2

Table B2-50. Tank 241-C-109 Analytical Results: Zinc (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	269	244	256.5[QC:f]
93-01361-A1T		Subsegment D Upper half	207	188	197.5
93-01361-A1B		Subsegment D Lower half	235	213	224
93-01361-A1B		Subsegment D Lower half	267	272	269.5

Table B2-50. Tank 241-C-109 Analytical Results: Zinc (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			µg/g	µg/g	µg/g
93-01367-A1T	49: 1	Subsegment D Upper half	217	273	245[QC:e,f]
93-01367-A1T		Subsegment D Upper half	170	221	195.5[QC:e]
93-01367-A1B		Subsegment D Lower half	181	210	195.5
93-01367-A1B		Subsegment D Lower half	220	269	244.5[QC:e]
93-01358-A1	Core 47	Solid composite	398	n/a	398
93-01358-A1		Solid composite	267	246	256.5
93-01363-A1	Core 48	Solid composite	196	195	195.5
93-01363-A2		Solid composite	n/a	277	277
93-01371-A1	Core 49	Solid composite	309	247	278[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	344	341	342.5[QC:f]
93-01356-H1		Subsegment C	251	274	262.5[QC:f]
93-01357-H1		Subsegment D	245	232	238.5[QC:f]
93-01360-H1	48: 1	Subsegment C	398	347	372.5[QC:f]
93-01361-H1		Subsegment D	346	269	307.5[QC:e,f]
93-01365-H1	49: 1	Subsegment B	664	619	641.5[QC:f]
93-01366-H1		Subsegment C	343	279	311[QC:e,f]
93-01367-H1		Subsegment D	323	380	351.5[QC:f]
93-01367-H1T		Subsegment D Upper half	317	372	344.5[QC:f]
93-01367-H1B		Subsegment D Lower half	278	273	275.5[QC:f]

Table B2-50. Tank 241-C-109 Analytical Results: Zinc (ICP). (3 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion (continued)			µg/g	µg/g	µg/g
93-01358-H1	Core 47	Solid composite	329	372	350.5[QC:f]
93-01363-H1	Core 48	Solid composite	370	320	345[QC:f]
93-01371-H1	Core 49	Solid composite	379	398	388.5[QC:f]
Solids: water digest			µg/g	µg/g	µg/g
93-01358-C1	Core 47	Solid composite	9	9	9[QC:f]
93-01363-C1	Core 48	Solid composite	8	9	8.5
93-01371-C1	Core 49	Solid composite	8	6	7[QC:e]
Drainable liquid: acid digest			µg/g	µg/g	µg/g
93-01354-A1	Tank composite	Liquid composite	10	11	11

Table B2-51. Tank 241-C-109 Analytical Results: Zirconium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
93-01361-A1T	48: 1	Subsegment D Upper half	17	14	15.5
93-01361-A1T		Subsegment D Upper half	16	14	15
93-01361-A1B		Subsegment D Lower half	3	14	8.5[QC:e]
93-01361-A1B		Subsegment D Lower half	< 8	11	< 9

Table B2-51. Tank 241-C-109 Analytical Results: Zirconium (ICP). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest (continued)			µg/g	µg/g	µg/g
93-01367-A1T	49: 1	Subsegment D Upper half	10	16	13[QC:e]
93-01367-A1T		Subsegment D Upper half	8	13	10.5[QC:e]
93-01367-A1B		Subsegment D Lower half	10	13	11.5[QC:e]
93-01367-A1B		Subsegment D Lower half	13	13	13
93-01358-A1	Core 47	Solid composite	4	3	3.5[QC:c,e]
93-01363-A1	Core 48	Solid composite	5	10	7.5[QC:e]
93-01371-A1	Core 49	Solid composite	5	< 2	< 3[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
93-01355-H1	47: 1	Subsegment B	53	< 23	< 38

Table B2-52. Tank 241-C-109 Analytical Results: Chloride (IC). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
93-01355-C1	47: 1	Subsegment B	500	600	550
93-01356-C1		Subsegment C	700	700	700
93-01357-C1		Subsegment D	800	700	750
93-01360-C1	48: 1	Subsegment C	1,000	900	950
93-01361-C1		Subsegment D	1,000	1,000	1,000[QC:e]

Table B2-52. Tank 241-C-109 Analytical Results: Chloride (IC). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
93-01365-C1	49: 1	Subsegment B	500	500	500
93-01366-C1		Subsegment C	800	800	800
93-01367-C1		Subsegment D	800	800	800
93-01358-C1	Core 47	Solid composite	700	700	700
Solids: water digest (continued)			**µg/g**	**µg/g**	**µg/g**
93-01363-C1	Core 48	Solid composite	800	800	800
93-01371-C1	Core 49	Solid composite	700	700	700
Drainable liquid: water digest			**µg/g**	**µg/g**	**µg/g**
93-01354-C1	Tank composite	Liquid composite	1,300	1,300	1,300

Table B2-53. Tank 241-C-109 Analytical Results: Fluoride (IC). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01355-C1	47: 1	Subsegment B	300	300	300[QC:c]
93-01356-C1		Subsegment C	300	300	300
93-01357-C1		Subsegment D	300	300	300
93-01360-C1	48: 1	Subsegment C	500	500	500
93-01361-C1		Subsegment D	1,100	400	750[QC:d,e]
93-01365-C1	49: 1	Subsegment B	< 300	< 300	< 300
93-01366-C1		Subsegment C	300	300	300
93-01367-C1		Subsegment D	1,000	900	950
93-01358-C1	Core 47	Solid composite	400	400	400

Table B2-53. Tank 241-C-109 Analytical Results: Fluoride (IC). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
93-01363-C1	Core 48	Solid composite	2,200	400	1,300[QC:e]
93-01371-C1	Core 49	Solid composite	400	400	400
Drainable liquid: water digest			**μg/g**	**μg/g**	**μg/g**
93-01354-C1	Tank composite	Liquid composite	< 200	< 200	< 200

Table B2-54. Tank 241-C-109 Analytical Results: Nitrate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**μg/g**	**μg/g**	**μg/g**
93-01355-C1	47: 1	Subsegment B	26,900	28,300	27,600[QC:d]
93-01356-C1		Subsegment C	36,000	36,000	36,000
93-01357-C1		Subsegment D	39,000	38,000	38,500
93-01360-C1	48: 1	Subsegment C	55,000	57,000	56,000
93-01361-C1		Subsegment D	52,000	55,000	53,500[QC:d]
93-01365-C1	49: 1	Subsegment B	25,200	26,200	25,700
93-01366-C1		Subsegment C	40,000	44,000	42,000[QC:d]
93-01367-C1		Subsegment D	44,000	42,000	43,000
93-01358-C1	Core 47	Solid composite	37,000	37,000	37,000
93-01363-C1	Core 48	Solid composite	45,000	51,000	48,000
93-01371-C1	Core 49	Solid composite	35,000	37,000	36,000
Drainable liquid: water digest			**μg/g**	**μg/g**	**μg/g**
93-01354-C1	Tank composite	Liquid composite	72,000	72,000	72,000[QC:d]

Table B2-55. Tank 241-C-109 Analytical Results: Nitrite (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
93-01355-C1	47: 1	Subsegment B	27,000	28,800	27,900
93-01356-C1		Subsegment C	37,000	37,000	37,000
93-01357-C1		Subsegment D	40,000	39,000	39,500
93-01360-C1	48: 1	Subsegment C	49,000	53,000	51,000
93-01361-C1		Subsegment D	49,000	50,000	49,500[QC:c]
93-01365-C1	49: 1	Subsegment B	25,800	27,100	26,500
93-01366-C1		Subsegment C	42,000	45,000	43,500
93-01367-C1		Subsegment D	46,000	44,000	45,000
Solids: water digest (continued)			µg/g	µg/g	µg/g
93-01358-C1	Core 47	Solid composite	38,000	40,000	39,000
93-01363-C1	Core 48	Solid composite	42,000	48,000	45,000
93-01371-C1	Core 49	Solid composite	38,000	39,000	38,500
Drainable liquid: water digest			µg/g	µg/g	µg/g
93-01354-C1	Tank composite	Liquid composite	71,000	71,000	71,000[QC:c]

Table B2-56. Tank 241-C-109 Analytical Results: Phosphate (IC). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
93-01355-C1	47: 1	Subsegment B	7,100	7,500	7,300
93-01356-C1		Subsegment C	9,600	9,500	9,550
93-01357-C1		Subsegment D	34,000	55,000	44,500[QC:e]
93-01360-C1	48: 1	Subsegment C	15,000	16,500	15,800
93-01361-C1		Subsegment D	38,000	34,000	36,000
93-01365-C1	49: 1	Subsegment B	6,000	6,200	6,100
93-01366-C1		Subsegment C	8,900	8,700	8,800[QC:c]

Table B2-56. Tank 241-C-109 Analytical Results: Phosphate (IC). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
93-01367-C1		Subsegment D	24,300	26,000	25,200
93-01358-C1	Core 47	Solid composite	20,100	24,000	22,100
93-01363-C1	Core 48	Solid composite	35,900	17,500	26,700[QC:e]
93-01371-C1	Core 49	Solid composite	13,500	12,000	12,800
Drainable liquid: water digest			**µg/g**	**µg/g**	**µg/g**
93-01354-C1	Tank composite	Liquid composite	13,500	13,500	13,500

Table B2-57. Tank 241-C-109 Analytical Results: Sulfate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**µg/g**	**µg/g**	**µg/g**
93-01355-C1	47: 1	Subsegment B	4,900	5,200	5,050
93-01356-C1		Subsegment C	7,100	7,100	7,100
93-01357-C1		Subsegment D	7,600	7,100	7,350
93-01360-C1	48: 1	Subsegment C	10,800	11,200	11,000
93-01361-C1		Subsegment D	10,000	10,000	10,000[QC:c]
93-01365-C1	49: 1	Subsegment B	4,500	4,800	4,650
93-01366-C1		Subsegment C	7,900	8,400	8,150
93-01367-C1		Subsegment D	7,900	8,300	8,100
93-01358-C1	Core 47	Solid composite	7,200	7,400	7,300
93-01363-C1	Core 48	Solid composite	8,900	9,600	9,250
93-01371-C1	Core 49	Solid composite	6,200	6,900	6,550
Drainable liquid: water digest			**µg/g**	**µg/g**	**µg/g**
93-01354-C1	Tank composite	Liquid composite	12,800	12,800	12,800

Table B2-58. Tank 241-C-109 Analytical Results: Cyanide. (Spectrscopy)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**$\mu g/g$**	**$\mu g/g$**	**$\mu g/g$**
93-01355-C1	47: 1	Subsegment B	550	590	570
93-01356-C1		Subsegment C	840	812	826
93-01357-C1		Subsegment D	910	900	905
93-01360-C1	48: 1	Subsegment C	1,470	1,480	1,480
93-01361-C1		Subsegment D	1,350	1,370	1,360
93-01365-C1	49: 1	Subsegment B	350	380	365
93-01366-C1		Subsegment C	620	670	645
93-01367-C1		Subsegment D	700	730	715
Solids: water digest (continued)			**$\mu g/g$**	**$\mu g/g$**	**$\mu g/g$**
93-01358-C1	Core 47	Solid composite	820	810	815
93-01363-C1	Core 48	Solid composite	1,230	1,320	1,280
93-01371-C1	Core 49	Solid composite	540	560	550
Drainable liquid: water digest			**$\mu g/g$**	**$\mu g/g$**	**$\mu g/g$**
93-01354-C1	Tank composite	Liquid composite	1,320	1,350	1,340

Table B2-59. Tank 241-C-109 Analytical Results: Ammonia (ISE).

Sample Number	Sample Location	Sample Portion	Result[1]	Duplicate[1]	Mean[1]
Solids: water digest			**μg N/g**	**μg N/g**	**μg N/g**
93-01358-C1	Core 47	Solid composite	44	43	44
93-01363-C1	Core 48	Solid composite	64	58	61
93-01371-C1	Core 49	Solid composite	52	57	55

Note:

[1]Reported as μg nitrogen per gram sample

Table B2-60. Tank 241-C-109 Analytical Results: Hexavalent Chromium (Colorimetric).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg/g	µg/g	µg/g
93-01358-C1	Core 47	Solid composite	48	46	47
93-01363-C1	Core 48	Solid composite	36	37	37
93-01371-C1	Core 49	Solid composite	29	60	45[QC:c]
93-01371-C1		Solid composite	27	NA	27

Note:

NA = not available: analysis not performed

Table B2-61. Tank 241-C-109 Analytical Results: Total Carbon (Persulfate Oxidation). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: direct			µg C/g	µg C/g	µg C/g
93-01355-J1	47: 1	Subsegment B	7,800	7,400	7,600
93-01356-J1		Subsegment C	7,100	7,300	7,200
93-01357-J1		Subsegment D	7,500	7,700	7,600
93-01360-J1	48: 1	Subsegment C	12,000	13,000	13,000
93-01361-J1		Subsegment D	9,500	9,400	9,500
93-01361-J1		Subsegment D	11,000	11,000	11,000
93-01365-J1	49: 1	Subsegment B	5,600	5,800	5,700
93-01366-J1		Subsegment C	8,600	9,000	8,800
93-01367-J1		Subsegment D	9,200	9,600	9,400
93-01358-J1	Core 47	Solid composite	8,800	9,100	9,000
93-01363-J1	Core 48	Solid composite	7,900	8,300	8,100
93-01371-J1	Core 49	Solid composite	7,200	8,500	7,900

Table B2-61. Tank 241-C-109 Analytical Results: Total Carbon (Persulfate Oxidation). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μg C/g	μg C/g	μg C/g
93-01358-C1	Core 47	Solid composite	7,880	8,140	8,010
93-01363-C1	Core 48	Solid composite	8,850	8,600	8,730
93-01371-C1	Core 49	Solid composite	6,750	6,730	6,740
Drainable liquid: water digest			μg C/g	μg C/g	μg C/g
93-01354-C1	Tank composite	Liquid composite	8,800	8,700	8,800

Table B2-62. Tank 241-C-109 Analytical Results: Total Inorganic Carbon (Persulfate Oxidation). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: direct			μg C/g	μg C/g	μg C/g
93-01355-J1	47: 1	Subsegment B	5,500	5,300	5,400
93-01356-J1		Subsegment C	5,000	5,400	5,200
93-01357-J1		Subsegment D	5,300	5,400	5,400
93-01360-J1	48: 1	Subsegment C	8,300	9,000	8,700
93-01361-J1		Subsegment D	6,500	6,300	6,400
93-01361-J1		Subsegment D	7,100	7,800	7,500
93-01365-J1	49: 1	Subsegment B	3,900	3,900	3,900
93-01366-J1		Subsegment C	6,500	6,700	6,600
93-01367-J1		Subsegment D	6,600	7,000	6,800
93-01358-J1	Core 47	Solid composite	5,800	5,800	5,800
93-01363-J1	Core 48	Solid composite	5,000	5,300	5,200
93-01371-J1	Core 49	Solid composite	5,100	5,700	5,400

Table B2-62. Tank 241-C-109 Analytical Results: Total Inorganic Carbon (Persulfate Oxidation). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg C/g	µg C/g	µg C/g
93-01358-C1	Core 47	Solid composite	5,420	5,990	5,710
93-01363-C1	Core 48	Solid composite	5,520	5,770	5,650
93-01371-C1	Core 49	Solid composite	4,540	4,290	4,420
Drainable liquid: water digest			µg C/g	µg C/g	µg C/g
93-01354-C1	Tank composite	Liquid composite	6,300	6,000	6,200

Table B2-63. Tank 241-C-109 Analytical Results: Total Organic Carbon (Persulfate Oxidation). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: direct			µg C/g	µg C/g	µg C/g
93-01355-J1	47: 1	Subsegment B	2,200	2,100	2,200[QC:d]
93-01356-J1		Subsegment C	2,000	2,000	2,000
93-01357-J1		Subsegment D	2,200	2,200	2,200
93-01360-J1	48: 1	Subsegment C	3,500	3,800	3,700
93-01361-J1		Subsegment D	3,000	3,100	3,100
93-01361-J1		Subsegment D	3,800	3,200	3,500
93-01365-J1	49: 1	Subsegment B	1,700	1,900	1,800
93-01366-J1		Subsegment C	2,100	2,300	2,200
93-01367-J1		Subsegment D	2,600	2,500	2,600
93-01358-J1	Core 47	Solid composite	3,000	3,300	3,200
93-01363-J1	Core 48	Solid composite	2,900	3,000	3,000
93-01371-J1	Core 49	Solid composite	2,100	2,800	2,500[QC:e]

Table B2-63. Tank 241-C-109 Analytical Results: Total Organic Carbon (Persulfate Oxidation). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			µg C/g	µg C/g	µg C/g
93-01358-C1	Core 47	Solid composite	2,460	2,150	2,310
93-01363-C1	Core 48	Solid composite	3,330	2,830	3,080
93-01371-C1	Core 49	Solid composite	2,210	2,440	2,330
Drainable liquid: water digest			µg C/g	µg C/g	µg C/g
93-01354-C1	Tank composite	Liquid composite	2,500	2,700	2,600

Table B2-64. Tank 241-C-109 Analytical Results: ETOX (Extractible Organic Halides).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			µg/g	µg/g	µg/g
93-01371-F1	Core 49	Solid composite	11	< 10	< 11

Table B2-65. Tank 241-C-109 Analytical Results: SVOA Target Analyte CRQLs.[1,2] (3 sheets)

Target Compound	Greatest CRQL[3] (µg/g)	Target Compound	Greatest CRQL[3] (µg/g)
Acenaphthene	< 24	4,6-Dinitro-2-methylphenol	< 120
Acenaphthylene	< 24	2,4-Dinitrophenol	< 120
Anthracene	< 24	2,4-Dinitrotoluene	< 24
Benzo(a)anthracene	< 24	2,6-Dinitrotoluene	< 24
Benzo(b)fluoranthene	< 24	Di-n-octylphthalate	< 24
Benzo(k)fluoranthene	< 24	Fluoranthene	< 24
Benzoic acid	< 120	Fluorene	< 24

Table B2-65. Tank 241-C-109 Analytical Results: SVOA Target Analyte CRQLs.[1,2] (3 sheets)

Target Compound	Greatest CRQL[3] (µg/g)	Target Compound	Greatest CRQL[3] (µg/g)
Benzo(ghi)perylene	< 24	Hexachlorobenzene	< 24
Benzo(a)pyrene	< 24	Hexachlorobutadiene	< 24
Benzyl alcohol	< 24	Hexachlorocyclopentadiene	< 24
Bis(2-chloroethoxy)methane	< 24	Hexachloroethane	< 24
Bis(2-chloroethyl) ether	< 24	Indeno(1,2,3-cd)pyrene	< 24
Bis(2-chloroisopropyl) ether	< 24	Isophorone	< 24
Bis(2-ethylhexyl) phthalate	< 24	2-Methylnaphthalene	< 24
4-Bromophenylphenyl ether	< 24	2-Methylphenol	< 24
Butylbenzylphthalate	< 24	4-Methylphenol	< 24
4-Chloroaniline	< 24	Naphthalene	< 24
4-Chloro-3-methylphenol	< 24	2-Nitroaniline	< 120
2-Chloronaphthalene	< 24	3-Nitroaniline	< 120
2-Chlorophenol	< 24	4-Nitroaniline	< 120
4-Chlorophenylphenyl ether	< 24	Nitrobenzene	< 24
Chrysene	< 24	2-Nitrophenol	< 24
Dibenz[a,h]anthracene	< 24	4-Nitrophenol	< 120
Dibenzofuran	< 24	N-Nitroso-di-n-propylamine	< 24
Di-n-butylphthalate	< 24[4]	N-Nitrosodiphenylamine	< 24
1,2-Dichlorobenzene	< 24	Pentachlorophenol	< 120
1,3-Dichlorobenzene	< 24	Phenanthrene	< 24
1,4-Dichlorobenzene	< 24	Phenol	< 24
3,3'-Dichlorobenzidine	< 47	Pyrene	< 24
2,4-Dichlorophenol	< 24	1,2,4-Trichlorobenzene	< 24
Diethylphthalate	< 24	2,4,5-Trichlorophenol	< 120

Table B2-65. Tank 241-C-109 Analytical Results: SVOA Target Analyte CRQLs.[1,2] (3 sheets)

Target Compound	Greatest CRQL[3] (μg/g)	Target Compound	Greatest CRQL[3] (μg/g)
2,4-Dimethylphenol	< 24	2,4,6-Trichlorophenol	< 24
Dimethylphthalate	< 24	---	---

Notes:

SVOA = semi-volatile organic analysis
CRQL = (USEPA) contract-required quantitation limit

[1]This table lists the target compounds that were analyzed under the U.S. Environmental Protection Agency's Contract Laboratory Program (CLP) protocol for semi-volatile organic compounds. The CLP protocol specifies a minimum Contract Required Quantitation Limit (CRQL). The CRQL is typically greater than the actual method detection limit for the semi-volatile organic analysis. However, when a given analyte was not detected above the actual method detection limit, the analyte was reported as being present at less than the CRQL rather than less than the smaller method detection limit. Actual method detection limits for the target analytes were not reported.

[2]The data in this table apply to sample numbers (core:composite) 93-01358-E1 (47:solid composite), 93-01371-E1 (49:solid composite), and 93-01354-E1 (47/49: drainable liquid composite).

[3]The largest CRQL for any given subsample is listed in this column. The less than sign indicates that the target analyte was not detected above the method detection limit; the CRQL value was reported instead of the actual method detection limit.

[4]Di-n-butylphthalate was detected in drainable liquid composite sample 93-01354-E1 at 7.7 μg/mL; this target analyte was also detected in the blank.

Table B2-66. Tank 241-C-109 Analytical Results: cis-2-Bromocyclohexanol (SVOA).[1]

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid			**µg/mL**	**µg/mL**	**µg/mL**
93-01354-E1	Tank composite	Liquid composite	25	n/d	< 25

Notes:

n/d = not detected; compound was not detected; no estimated method detection limit was given but was assumed to be less than the replicate sample's detected value

[1]Compound is a tentatively identified compound based on the nearest library match to the compound's mass spectrum. This compound may or may not actually be present in the original tank waste. The compound's concentration was estimated using the response factor of the nearest-eluting internal standard.

Table B2-67. Tank 241-C-109 Analytical Results: Total Uranium (LF).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			**µg/g**	**µg/g**	**µg/g**
93-01358-H1	Core 47	Solid composite	11,700	12,200	12,000
93-01363-H1	Core 48	Solid composite	30,000	25,100	27,600
93-01371-H1	Core 49	Solid composite	7,630	7,420	7,530
Drainable liquid: direct filtered			**µg/g**	**µg/g**	**µg/g**
93-01354-N1	Tank composite	Liquid composite	3,000	3,150	3,080

Table B2-68. Tank 241-C-109 Analytical Results: Plutonium Isotopic Mass Percent (Mass Spectroscopy).

Run	Pu-238 Mass %	Pu-239 Mass %	Pu-240 Mass %	Pu-241 Mass %	Pu-242 Mass %
Core 47, Solid Composite, Sample Number 93-01358-H1: fusion[1]					
Result	0.0053	93.3295	6.52	0.1214	0.0239
Duplicate	0.0051	93.1179	6.7311	0.1217	0.0242
Mean	0.0052	93.2237	6.6256	0.1216	0.0241
Core 48, Solid Composite, Sample Number 93-01363-H1: fusion[2]					
Result	0.0052	97.8337	2.1208	0.029	0.0113
Duplicate	0.0167	97.4374	2.4782	0.0438	0.0239
Mean	0.0110[QC:e]	97.6355	2.2995	0.0364[QC:e]	0.0176[QC:e]
Core 49, Solid Composite, Sample Number 93-01371-H1: fusion[3]					
Result	0.0106	94.988	4.8456	0.1212	0.0346
Duplicate	0.0171	94.9378	4.9115	0.1025	0.0311
Mean	0.0139[QC:e]	94.9629	4.8786	0.1119	0.0329

Notes:

[1]Sample (result) and duplicate analyzed February 1, 1993.

[2]Sample (result) and duplicate analyzed January 28, 1993.

[3]Sample (result) analyzed January 28, 1993; duplicate analyzed January 29, 1993.

Table B2-69. Tank 241-C-109 Analytical Results: Uranium Isotopic Mass Percent (Mass Spectroscopy). (2 sheets)

Run	U-234 Mass %	U-235 Mass %	U-236 Mass %	U-238 Mass %
Core 47, Solid Composite, Sample Number 93-01358-H1: fusion[1]				
Result	0.0059	0.658	0.01	99.3261
Duplicate	0.0062	0.6566	0.0107	99.3265
Mean	0.0061	0.6573	0.0104	99.3263
Core 48, Solid Composite, Sample Number 93-01363-H1: fusion[2]				
Result	0.0056	0.682	0.0059	99.3065
Duplicate	0.0058	0.6883	0.0049	99.301
Mean	0.0057	0.6852	0.0054	99.3038

Table B2-69. Tank 241-C-109 Analytical Results: Uranium Isotopic Mass Percent (Mass Spectroscopy). (2 sheets)

Run	U-234 Mass %	U-235 Mass %	U-236 Mass %	U-238 Mass %
Core 49, Solid Composite, Sample Number 93-01371-H1: fusion[2]				
Result	0.0051	0.6792	0.0079	99.3077
Duplicate	0.0057	0.6713	0.0089	99.3141
Mean	0.0054	0.6753	0.0084	99.3109

Notes:

[1]Sample (result) and duplicate analyzed January 20, 1993.

[2]Sample (result) and duplicate analyzed January 21, 1993.

Table B2-70. Tank 241-C-109 Analytical Results: Total Alpha (Alpha Rad). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**µCi/g**	**µCi/g**	**µCi/g**
93-01361-A1T[1]	48: 1	Subsegment D Upper half	0.0618	0.0500	0.0559[QC:e]
92-01361-A1B[2]		Subsegment D Lower half	0.0674	0.0526	0.0600[QC:e]
93-01367-A1T[1]	49: 1	Subsegment D Upper half	0.0358	0.0594	0.0476[QC:e]
93-01367-A1B[2]		Subsegment D Lower half	0.0446	0.0523	0.0485
Solids: water digest			**µCi/g**	**µCi/g**	**µCi/g**
93-01358-C1[3]	Core 47	Solid composite	0.00508	0.00459	0.00484
93-01363-C1[4]	Core 48	Solid composite	1.37E-04	1.32E-04	1.35E-04
93-01371-C1[4]	Core 49	Solid composite	6.91E-04	5.58E-04	6.25E-04[QC:e]

Table B2-70. Tank 241-C-109 Analytical Results: Total Alpha (Alpha Rad). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			**µCi/g**	**µCi/g**	**µCi/g**
93-01367-H1T[5]	49: 1	Subsegment D Upper half	0.0454	0.0482	0.0468
93-01367-H1B[6]	49: 1	Subsegment D Lower half	0.0466	0.0489	0.0478
93-01358-H1[7]	Core 47	Solid composite	0.924	1.06	0.992
93-01363-H1[8]	Core 48	Solid composite	0.0579	0.0712	0.0646[QC:e]
93-01371-H1[9]	Core 49	Solid composite	0.122	0.136	0.129
Drainable liquid: direct filtered			**µCi/mL**	**µCi/mL**	**µCi/mL**
93-01354-N1[10]	Tank composite	Liquid composite	< 5E-05	< 5E-05	< 5E-05

Notes:

[1]Sample (result) and duplicate analyzed November 18, 1992.
[2]Sample (result) and duplicate analyzed November 19, 1992.
[3]Sample (result) analyzed December 30, 1992; duplicate analyzed December 31, 1992.
[4]Sample (result) and duplicate analyzed January 6, 1993.
[5]Sample (result) and duplicate analyzed December 4, 1992.
[6]Sample (result) analyzed December 4, 1992; duplicate analyzed December 7, 1992.
[7]Sample (result) and duplicate analyzed January 18, 1993.
[8]Sample (result) and duplicate analyzed January 15, 1993.
[9]Sample (result) analyzed January 15, 1993; duplicate analyzed January 18, 1993.
[10]Sample (result) and duplicate analyzed February 5, 1993.

Table B2-71. Tank 241-C-109 Analytical Results: Americium-241 (Alpha).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
93-01358-H1[1]	Core 47	Solid composite	0.250	0.390	0.320[QC:e]
93-01363-H1[2]	Core 48	Solid composite	0.00888	0.0113	0.0101[QC:e]
93-01371-H1[3]	Core 49	Solid composite	0.131	0.135	0.133

Notes:

[1]Sample (result) and duplicate analyzed January 26, 1993.

[2]Sample (result) analyzed January 26, 1993; duplicate analyzed January 27, 1993.

[3]Sample (result) and duplicate analyzed February 8, 1993.

Table B2-72. Tank 241-C-109 Analytical Results: Neptunium-237 (Alpha).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
93-01358-H1[1]	Core 47	Solid composite	3.97E-04	3.33E-04	3.65E-04
93-01363-H1[2]	Core 48	Solid composite	4.07E-04	2.60E-04	3.34E-04[QC:e]
93-01371-H1[3]	Core 49	Solid composite	2.53E-04	3.48E-04	3.01E-04[QC:e]

Notes:

[1]Sample (result) and duplicate analyzed February 8, 1993.

[2]Sample (result) analyzed February 8, 1993; duplicate analyzed February 5, 1993.

[3]Sample (result) analyzed February 5, 1993; duplicate analyzed February 8, 1993.

Table B2-73. Tank 241-C-109 Analytical Results: Total Alpha Pu (Alpha).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
93-01358-H1[1]	Core 47	Solid composite	0.805	0.949	0.877
93-01363-H1[2]	Core 48	Solid composite	0.0695	0.0666	0.0681
93-01371-H1[3]	Core 49	Solid composite	0.0659	0.0921	0.0790[QC:e]

Notes:

[1]Sample (result) and duplicate analyzed January 13, 1993.
[2]Sample (result) analyzed January 13, 1993; duplicate analyzed January 14, 1993.
[3]Sample (result) and duplicate analyzed January 14, 1993.

Table B2-74. Tank 241-C-109 Analytical Results: Strontium-90 (Beta Rad). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
93-01355-H1[1]	47: 1	Subsegment B	4,600	4,510	4,560
93-01356-H1[1]		Subsegment C	456	482	469
93-01357-H1[2]		Subsegment D	231	199	215
93-01360-H1[1]	48: 1	Subsegment C	159	144	152
93-01361-H1[3]		Subsegment D	127	114	121
93-01365-H1[3]	49: 1	Subsegment B	2,560	2,230	2,400
93-01366-H1[3]		Subsegment C	202	189	196
93-01367-H1[3]		Subsegment D	188	197	193
93-01358-H1[4]	Core 47	Solid composite	1,050	1,300	1,180[QC:e]
93-01363-H1[4]	Core 48	Solid composite	190	190	190
93-01371-H1[4]	Core 49	Solid composite	877	986	932

Table B2-74. Tank 241-C-109 Analytical Results: Strontium-90 (Beta Rad). (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid: direct filtered			µCi/g	µCi/g	µCi/g
93-01354-N1[4]	Tank composite	Liquid composite	0.0107	0.0096	0.0102

Notes:

[1]Sample (result) and duplicate analyzed December 30, 1992.
[2]Sample (result) analyzed January 27, 1993; duplicate analyzed December 30, 1992.
[3]Sample (result) and duplicate analyzed December 23, 1992.
[4]Sample (result) and duplicate analyzed January 27, 1993.

Table B2-75. Tank 241-C-109 Analytical Results: Technetium-99 (Beta Rad).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
93-01358-H1[1]	Core 47	Solid composite	0.107	0.109	0.108
93-01363-H1[1]	Core 48	Solid composite	0.117	0.114	0.116
93-01371-H1[2]	Core 49	Solid composite	0.0936	0.0951	0.0945
Drainable liquid: direct filtered			µCi/g	µCi/g	µCi/g
93-01354-N1[3]	Tank composite	Liquid composite	0.154	0.158	0.156
Drainable liquid: acid digest			µCi/g	µCi/g	µCi/g
93-01354-N1	Tank composite	Liquid composite	0.154	0.158	0.156

Notes:

[1]Sample (result) and duplicate analyzed January 12, 1993.
[2]Sample (result) and duplicate analyzed January 13, 1993.
[3]Sample (result) and duplicate analyzed February 9, 1993.

Table B2-76. Tank 241-C-109 Analytical Results: Total Beta (Beta Rad).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			**µCi/g**	**µCi/g**	**µCi/g**
93-01358-H1[1]	Core 47	Solid composite	2,940	2,550	2,750
93-01363-H1[1]	Core 48	Solid composite	1,410	1,200	1,310
93-01371-H1[1]	Core 49	Solid composite	2,420	2,170	2,300
Solids: water digest			**µCi/g**	**µCi/g**	**µCi/g**
93-01358-C1[2]	Core 47	Solid composite	13.8	20.9	17.4[QC:e]
93-01363-C1[2]	Core 48	Solid composite	7.49	9.70	8.60[QC:e]
93-01371-C1[2]	Core 49	Solid composite	9.04	8.43	8.74
Drainable liquid: direct filtered			**µCi/g**	**µCi/g**	**µCi/g**
93-01354-N1[3]	Tank composite	Liquid composite	5.40	5.46	5.43
Drainable liquid: acid digest			**µCi/g**	**µCi/g**	**µCi/g**
93-01354-N1[3]	Tank composite	Liquid composite	5.4	5.46	5.43

Notes:

[1]Sample (result) and duplicate analyzed January 14, 1993.
[2]Sample (result) and duplicate analyzed January 5, 1993.
[3]Sample (result) and duplicate analyzed January 26, 1993.

Table B2-77. Tank 241-C-109 Analytical Results: Americium-241 (GEA).[1]

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			**μCi/g**	**μCi/g**	**μCi/g**
93-01355-H1	47: 1	Subsegment B	0.809	0.692	0.751
93-01356-H1		Subsegment C	< 0.48	< 0.48	< 0.48
93-01357-H1		Subsegment D	< 0.60	< 0.51	< 0.56
93-01360-H1	48: 1	Subsegment C	< 0.55	< 0.63	< 0.59
93-01361-H1		Subsegment D	< 0.63	< 0.63	< 0.63
93-01365-H1	49: 1	Subsegment B	0.594	0.446	0.520[QC:c]
93-01366-H1		Subsegment C	< 0.23	< 0.042	< 0.14
93-01367-H1		Subsegment D	< 0.26	< 0.27	< 0.27
93-01358-H1	Core 47	Solid composite	< 0.56	< 0.59	< 0.58
93-01363-H1	Core 48	Solid composite	< 0.75	< 0.67	< 0.71
93-01371-H1	Core 49	Solid composite	< 0.35	< 0.35	< 0.35
Solids: water digest			**μCi/g**	**μCi/g**	**μCi/g**
93-01358-C1	Core 47	Solid composite	< 0.0039	< 0.0040	< 0.0040
93-01363-C1	Core 48	Solid composite	< 0.0033	< 0.0039	< 0.0036
93-01371-C1	Core 49	Solid composite	< 0.0030	< 0.0028	< 0.0029
Drainable liquid: direct filtered			**μCi/mL**	**μCi/mL**	**μCi/mL**
93-01355-N1	Tank composite	Liquid composite	< 0.0014	< 0.0014	< 0.0014

Note:

[1]All results decay corrected to January 1, 1992.

Table B2-78. Tank 241-C-109 Analytical Results: Cesium-137 (GEA).[1] (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			**μCi/g**	**μCi/g**	**μCi/g**
93-01361-A1T	48: 1	Subsegment D Upper half	8.52	15.6	12.1[QC:e,f]
92-01361-A1B		Subsegment D Lower half	8.81	14.3	11.6[QC:e,f]
93-01367-A1T	49: 1	Subsegment D Upper half	35.4	43.4	39.4[QC:e,f]
93-01367-A1B		Subsegment D Lower half	19.3	27.4	23.4[QC:e,f]
Solids: fusion			**μCi/g**	**μCi/g**	**μCi/g**
93-01355-H1	47: 1	Subsegment B	317	357	337
93-01356-H1		Subsegment C	812	731	772
93-01357-H1		Subsegment D	971	923	947
93-01360-H1	48: 1	Subsegment C	1,170	1,140	1,160
93-01361-H1		Subsegment D	1,220	1,110	1,170
93-01365-H1	49: 1	Subsegment B	121	115	118
93-01366-H1		Subsegment C	553	144	349[QC:e]
93-01367-H1		Subsegment D	660	743	702
93-01367-H1T		Subsegment D Upper half	713	750	732
93-01367-H1B		Subsegment D Lower half	696	700	698
93-01358-H1	Core 47	Solid composite	870	877	874
93-01363-H1	Core 48	Solid composite	1,110	952	1,030
93-01371-H1	Core 49	Solid composite	547	566	557

Table B2-78. Tank 241-C-109 Analytical Results: Cesium-137 (GEA).[1] (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**µCi/g**	**µCi/g**	**µCi/g**
93-01358-C1	Core 47	Solid composite	9.07	9.40	9.24
93-01363-C1	Core 48	Solid composite	7.95	10.7	9.33[QC:e]
93-01371-C1	Core 49	Solid composite	5.61	4.95	5.28
Drainable liquid: direct filtered			**µCi/mL**	**µCi/mL**	**µCi/mL**
93-01354-N1	Tank composite	Liquid composite	5.60	5.62	5.61

Note:
[1]All results decay corrected to January 1, 1992.

Table B2-79. Tank 241-C-109 Analytical Results: Cobalt-60 (GEA).[1] (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			**µCi/g**	**µCi/g**	**µCi/g**
93-01355-H1	47: 1	Subsegment B	< 0.032	< 0.023	< 0.028
93-01356-H1		Subsegment C	< 0.022	< 0.027	< 0.025
93-01357-H1		Subsegment D	< 0.023	< 0.016	< 0.020
93-01360-H1	48: 1	Subsegment C	< 0.017	< 0.014	< 0.016
93-01361-H1		Subsegment D	< 0.016	< 0.015	< 0.016
93-01365-H1	49: 1	Subsegment B	< 0.013	< 0.013	< 0.013
93-01366-H1		Subsegment C	< 0.011	< 0.0016	< 0.006
93-01367-H1		Subsegment D	< 0.011	< 0.011	< 0.011
93-01358-H1	Core 47	Solid composite	< 0.025	< 0.023	< 0.024
93-01363-H1	Core 48	Solid composite	< 0.024	< 0.029	< 0.027
93-01371-H1	Core 49	Solid composite	< 0.012	< 0.015	< 0.014

Table B2-79. Tank 241-C-109 Analytical Results: Cobalt-60 (GEA).[1] (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**μCi/g**	**μCi/g**	**μCi/g**
93-01358-C1	Core 47	Solid composite	7.27E-04	6.47E-04	6.87E-04
93-01363-C1	Core 48	Solid composite	9.53E-04	0.0011	0.0010
93-01371-C1	Core 49	Solid composite	5.73E-04	6.88E-04	6.31E-04
Drainable liquid: direct filtered			**μCi/mL**	**μCi/mL**	**μCi/mL**
93-01354-N1	Tank composite	Liquid composite	0.00146	0.00145	0.00146

Note:
[1]All results decay corrected to January 1, 1992.

Table B2-80. Tank 241-C-109 Analytical Results: Europium-154 (GEA).[1] (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			**μCi/g**	**μCi/g**	**μCi/g**
93-01355-H1	47: 1	Subsegment B	0.954	0.810	0.882
93-01356-H1		Subsegment C	< 0.13	< 0.13	< 0.13
93-01357-H1		Subsegment D	< 0.12	< 0.10	< 0.11
93-01360-H1	48: 1	Subsegment C	< 0.077	< 0.074	< 0.076
93-01361-H1		Subsegment D	< 0.090	< 0.10	< 0.095
93-01365-H1	49: 1	Subsegment B	0.949	0.609	0.779[QC:e]
93-01366-H1		Subsegment C	< 0.064	< 0.013	< 0.039
93-01367-H1		Subsegment D	< 0.063	< 0.061	< 0.062
93-01358-H1	Core 47	Solid composite	< 0.24	< 0.25	< 0.25
93-01363-H1	Core 48	Solid composite	< 0.072	< 0.073	< 0.073
93-01371-H1	Core 49	Solid composite	0.390	0.333	0.362

Table B2-80. Tank 241-C-109 Analytical Results: Europium-154 (GEA).[1] (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**µCi/g**	**µCi/g**	**µCi/g**
93-01358-C1	Core 47	Solid composite	< 0.0020	< 0.0024	< 0.0022
93-01363-C1	Core 48	Solid composite	< 7.6E-04	< 5.5E-04	< 6.6E-04
93-01371-C1	Core 49	Solid composite	< 0.0017	< 0.0012	< 0.0015
Drainable liquid: direct filtered			**µCi/mL**	**µCi/mL**	**µCi/mL**
93-01354-N1	Tank composite	Liquid composite	< 2.8E-04	< 3.2E-04	< 3.0E-04

Note:

[1]All results decay corrected to January 1, 1992.

Table B2-81. Tank 241-C-109 Analytical Results: Europium-155 (GEA).[1] (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			**µCi/g**	**µCi/g**	**µCi/g**
93-01355-H1	47: 1	Subsegment B	0.882	1.43	1.16[QC:e]
93-01356-H1		Subsegment C	< 0.86	< 0.86	< 0.86
93-01357-H1		Subsegment D	< 1.1	< 0.94	< 1.0
93-01360-H1	48: 1	Subsegment C	< 1.0	< 1.2	< 1.1
93-01361-H1		Subsegment D	< 1.2	< 1.2	< 1.2
93-01365-H1	49: 1	Subsegment B	1.19	0.667	0.929[QC:e]
93-01366-H1		Subsegment C	< 0.42	< 0.083	< 0.25
93-01367-H1		Subsegment D	< 0.47	< 0.51	< 0.49
93-01358-H1	Core 47	Solid composite	< 0.84	< 0.88	< 0.86
93-01363-H1	Core 48	Solid composite	< 1.2	< 1.1	< 1.2
93-01371-H1	Core 49	Solid composite	< 0.53	< 0.51	< 0.52

Table B2-81. Tank 241-C-109 Analytical Results: Europium-155 (GEA).[1] (2 sheets)

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**μCi/g**	**μCi/g**	**μCi/g**
93-01358-C1	Core 47	Solid composite	< 0.0080	< 0.0081	< 0.0081
93-01363-C1	Core 48	Solid composite	< 0.0070	< 0.0081	< 0.0076
93-01371-C1	Core 49	Solid composite	< 0.0061	< 0.0057	< 0.0059
Drainable liquid: direct filtered			**μCi/mL**	**μCi/mL**	**μCi/mL**
93-01354-N1	Tank composite	Liquid composite	< 0.0024	< 0.0024	< 0.0024

Note:

[1]All results decay corrected to January 1, 1992.

Table B2-82. Tank 241-C-109 Analytical Results: Tritium (Liquid. Scintillation).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**μCi/g**	**μCi/g**	**μCi/g**
93-01358-C1[1]	Core 47	Solid composite	0.00714	0.00989	0.00852[QC:e,f]
93-01363-C1[1]	Core 48	Solid composite	0.00615	0.00673	0.00644
93-01371-C1[1]	Core 49	Solid composite	0.00723	0.00547	0.00635[QC:e]
Drainable liquid: direct filtered			**μCi/g**	**μCi/g**	**μCi/g**
93-01354-N1[2]	Tank composite	Liquid composite	0.00328	0.00329	0.00329

Notes:

[1]Sample (result) and duplicate analyzed January 7, 1993.

[2]Sample (result) and duplicate analyzed February 2, 1993.

Table B2-83. Tank 241-C-109 Analytical Results: Carbon-14 (Liquid Scintillation).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			μCi/mL	μCi/mL	μCi/mL
93-01358-C1[1]	Core 47	Solid composite	< 5.0E-06	0	< 5.6E-06
93-01363-C1[1]	Core 48	Solid composite	0	0	1.8E-05[QC:e]
93-01371-C1[1]	Core 49	Solid composite	0	0	3.6E-05
Drainable liquid: direct filtered			μCi/mL	μCi/mL	μCi/mL
93-01354-N1[2]	Tank composite	Liquid composite	0.0025	0.0024	0.0025

Notes:

[1]Sample (result) and duplicate analyzed February 4, 1993.

[2]Sample (result) and duplicate analyzed February 5, 1993.

Table B2-84. Tank 241-C-109 Analytical Results: Selenium-79 (Liquid Scintillation).[1]

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			μCi/g	μCi/g	μCi/g
93-01358-H1	Core 47	Solid composite	< 8E-05	< 8E-05	< 8E-05
93-01363-H1	Core 48	Solid composite	< 6E-05	< 5E-05	< 6E-05
93-01371-H1	Core 49	Solid composite	< 5E-05	5E-05	< 5E-05

Note:

[1]Sample (result) and duplicate analyzed January 14, 1993.

Table B2-85. Tank 241-C-109 Analytical Results: Density (Physical Properties).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Drainable liquid			**g/mL**	**g/mL**	**g/mL**
NA	47: 1	Drainable liquid	1.1	NA	1.1
NA	49: 1	Drainable liquid	1.1	NA	1.1
Solids			**g/mL**	**g/mL**	**g/mL**
NA	47: 1	Whole	1.2	NA	1.2
NA	48: 1	Whole	1.3	NA	1.3
NA	49: 1	Whole	1.2	NA	1.2

Note:

NA = not available: sample densities were estimated in the hot cell on the freshly extruded samples before the assignment of sample numbers; estimates were not performed in duplicate

Table B2-86. Tank 241-C-109 Analytical Results: Percent Solids (gravimetric).[1]

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids			**wt%**	**wt%**	**wt%**
93-01355-K1	47: 1	Subsegment B	82.02	79.39	80.71
93-01356-K1		Subsegment C	71.93	71.37	71.65
93-01357-K1		Subsegment D	60.48	60.64	60.56
93-01360-K1	48: 1	Subsegment C	46.57	47.74	47.15
93-01361-K1		Subsegment D	47.82	48.88	48.35
93-01365-K1	49: 1	Subsegment B	78.78	82.05	80.42
93-01366-K1		Subsegment C	59.78	63.56	61.67
93-01367-K1		Subsegment D	60.02	60.72	60.37
93-01358-K1	Core 47	Solid composite	77.30	79.62	78.46
93-01363-K1	Core 48	Solid composite	43.19	41.36	42.28
93-01371-K1	Core 49	Solid composite	71.61	72.79	72.20

Note:

[1]Samples dried at 105 °C (221 °F) for 24 hours.

Table B2-87. Tank 241-C-109 Analytical Results: pH Measurement (pH).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: water digest			**pH**	**pH**	**pH**
93-01355-C1	47: 1	Subsegment B	8.92	8.71	8.82
93-01356-C1		Subsegment C	9.61	9.68	9.65
93-01357-C1		Subsegment D	10.06	10.36	10.21
93-01360-C1	48: 1	Subsegment C	9.21	10.17	9.69
93-01361-C1		Subsegment D	11.09	10.88	10.99
93-01365-C1	49: 1	Subsegment B	10.15	10.29	10.22
93-01366-C1		Subsegment C	10.49	10.57	10.53
93-01367-C1		Subsegment D	10.95	10.94	10.95
93-01358-C1	Core 47	Solid composite	10.7	10.8	10.75
93-01363-C1	Core 48	Solid composite	9.73	10.42	10.08
93-01371-C1	Core 49	Solid composite	8.87	9.86	9.37
Drainable liquid: direct filtered			**pH**	**pH**	**pH**
93-01354-N	Tank composite	Liquid composite	12.08	n/a	12.08

Table B2-88. Tank 241-C-109 Analytical Results: Thermogravimetric Analysis (TGA) Transition 1.

Sample Number	Sample Location	Sample Portion	Run	Range	Mass Loss	Mean
Solids				°C	wt%	wt%
93-03117	47: 1	Subsegment B	Result	31-150	10	10.2
			Duplicate	31-150	10.4	
93-03118		Subsegment C	Result	31-150	18.1	18.1
			Duplicate	31-150	18	
93-03119		Subsegment D	Result	31-150	19.7	19.7
			Duplicate	31-150	19.7	
93-03121	48: 1	Subsegment D	Result	31-180	46.4	45.1
			Duplicate	31-180	43.8	
93-03122	49: 1	Subsegment B	Result	31-180	2.4	4.2[QC:e]
			Duplicate	31-180	6	
93-03123		Subsegment C	Result	31-180	28.6	29.6
			Duplicate	31-180	30.6	
93-03124		Subsegment D	Result	31-180	29.6	29.3
			Duplicate	31-180	29	
93-01358	Core 47	Solid composite	Result	31-150	15.6	14.8
			Duplicate	31-150	14	
93-01371	Core 49	Solid composite	Result	31-180	27.5	26.6
			Duplicate	31-180	25.6	

B2.2 1995 VAPOR SAMPLING

B2.2.1 Description of 1995 Vapor Sampling Event

Vapor sampling to support the vapor DQO (Osborne et al. 1994) was performed on August 10, 1995 using the vapor sampling system (VSS). Air from the tank 241-C-109 headspace was withdrawn via a 7.9-m (26-ft) long heated sampling probe mounted in riser 4, and transferred through heated tubing to the VSS sampling manifold. All heated zones of the VSS were maintained at approximately 50 °C (120 °F) (Huckaby and Bratzel 1995).

Samples were collected in SUMMA[1] canisters or various types of sorbent traps. Samples collected in a triple sorbent trap device were analyzed by Oak Ridge National Laboratories (ORNL) for organic vapors. Pacific Northwest National Laboratory (PNNL) and the Oregon Graduate Institute of Science and Technology (OGIST) analyzed both SUMMA™ and sorbent trap devices for inorganic and organic vapors. Due to differences in documenting quality assurance measures between ORNL, OGIST, and PNNL, PNNL SUMMA™ sample results should be considered the primary vapor data for tank 241-C-109. Detailed descriptions of the sampling event are reported in *Vapor and Gas Sampling of Single-Shell Tank 241-C-109 Using the Vapor Sampling System* (Caprio 1995).

B2.2.2 Analytical Results

A summary of results from the vapor sampling event is presented in Table B2-89. Only quantitatively measured analytes are reported. A complete table of results may be found in Huckaby and Bratzel (1995). Both PNNL and OGIST report target analyte concentrations in ppmv of analyte in dry air.

Table B2-89. Quantitatively Measured Compounds Collected from the Headspace of Tank 241-C-109.[1] (2 sheets)

Analyte	Vapor Concentration (PNNL) ppmv	Vapor Concentration (OGIST)[2] ppmv
Inorganic analytes		
NH_3	10.1	---
CO_2	---	3
CO	---	0.41
H_2	---	125
NO	0.51	---
NO_2	$\leq$ 0.06	---
N_2O	---	369
H_2O	28,400	---
Organic analytes		
Trichlorofluoromethane	0.0071	---

[1]SUMMA is a trademark of Molectrics, Cleveland, Ohio.

Table B2-89. Quantitatively Measured Compounds Collected from the Headspace of Tank 241-C-109.[1] (2 sheets)

Analyte	Vapor Concentration (PNNL)	Vapor Concentration (OGIST)[2]
	ppmv	ppmv
Methane	---	0.927
Total non-methane organic constituents	---	0.65

Note:

[1]Huckaby and Bratzel (1995)

[2]OGIST date is not considered appropriately qualified information, and are not suitable for decision making.

B2.3 HISTORICAL SAMPLING EVENTS

B2.3.1 September, 1975 - Supernatant Sample

Analysis of a liquid sample from tank 241-C-109, received at the laboratory on June 19, 1975, was reported in Wheeler (1975). The results are provided in Table B2-90. No information was available regarding sample handling or analytical methods.

Table B2-90. Grab Sample Results from September 19, 1975, for Tank 241-C-109.[1] (2 sheets)

Component	Lab Value[2]	Lab Unit
Physical Data		
Vis-OTR	Light yellow, no solids. 300 mrad/hr at 4 in.	
Percent water	73.54	%
Specific gravity	1.212	---
pH	12.5	---
Chemical Analysis		
OH	0.768	*M*
Al	0.0626	*M*
NO_2^-	3.07	*M*
NO_3^-	0.790	*M*

Table B2-90. Grab Sample Results from September 19, 1975, for Tank 241-C-109.[1]
(2 sheets)

Component	Lab Value[2]	Lab Unit
Radiological Analysis		
$^{89/90}Sr$	2,530	μCi/gal
^{134}Cs	887	μCi/gal
^{137}Cs	5.64E+05	μCi/gal

Note:
[1]Wheeler (1975)
[2]No QC information was provided with the results.

Cooling curve measurements showed no solids formation down to 5 °C (41 °F). Differential thermal analysis showed no exotherms below 200 °C (392 °F).

B2.3.2 April 1980 - Particle Size Sample

Analysis of dried solids from tank 241-C-109 was reported in Jansky (1980). A summary of the results are provided in Table B2-91. No information was available regarding sample handling methods.

Table B2-91. 1980 Particle Size Data (Jansky 1980)[1].

	Mean	Standard Deviation	Skewness
Geometric Count	30.07 μm	11.09 μm	0.65
Arithmetic Count	31.79 μm	12.29 μm	0.73
Mode	22.86 μm		
Median	28.14 μm		

Note:
No QC information was provided with the results.

B2.3.3 November 1990 - Supernatant Sample

Analysis of a liquid sample from tank 241-C-109 was reported in Edrington (1990). The results are provided in Table B2-92. No specific information was available regarding sample handling or analytical methods.

Table B2-92. 1990 Anion Concentration (Edrington 1990).

Analyte[1]	Concentration
Total Organic Carbon	0.63 g/L
Nitrite	23,000 μg/g
Nitrate	135,000 μg/g
Carbonate	0.25 *M*
Sulfate	21,000 μg/g
Phosphate	8,8000 μg/g
Hydroxide	0.50 *M*

Note:

No QC information was provided with the results.

B2.3.4 August 1992 - Vapor Sample

Analysis of a vapor sample in August, 1992 found no combustible gases in the tank's vapor space (Fowler 1992).

B3.0 ASSESSMENT OF CHARACTERIZATION RESULTS

The purpose of this chapter is to discuss the overall quality and consistency of the current sampling results for tank 241-C-109, and to present the results of the calculation of an analytical-based inventory.

This section also evaluates sampling and analysis factors that may impact interpretation of the data. These factors are used to assess the overall quality and consistency of the data and to identify any limitations in the use of the data.

B3.1 FIELD OBSERVATIONS

No problems were noted during the sampling event which would impact the analytical results. However, liner liquid was discovered in the shipping casks containing the core 47 and core 49 samplers. Leaking samplers represent a potential safety concern due to compromise of sample containment. No further anomalies during sampling or analysis were reported.

B3.2 QUALITY CONTROL ASSESSMENT

The QC assessment from the 1992 core sampling event are discussed in Section B3.2.1, and the QC results from the 1994 vapor sampling event are discussed in Section B3.2.2.

B3.2.1 Quality Control Assessment for the 1992 Core Sampling Event

The usual QC assessment includes an evaluation of the appropriate standard recoveries, spike recoveries, duplicate analyses, and blanks that are performed in conjunction with the chemical analyses. All the pertinent quality control tests were conducted on the 1992 core samples, allowing a full assessment regarding the accuracy and precision of the data. However, under the proscribed sampling and analysis plan (Hill et al. 1991; Hill 1991), there were no specific QC acceptance criteria. The specific criteria for all QC checks applied in this assessment were given in DOE (1995). Sample and duplicate pairs that had one or more QC results outside the specified criteria were identified by subscripts in the data summary tables.

The standard and spike recovery results provide an estimate of the accuracy of the analysis. If a standard or spike recovery is above or below the given criterion, the analytical results may be biased high or low, respectively. All standard recoveries were within the defined limits. Spike recoveries outside the limits for ICP analytes were because of the high dilutions required. These high dilution factors can cause poor or meaningless spike recoveries and RPDs for those ICP elements that had either very high concentrations or were close to the detection limit. All fusion digested results require high dilutions, which affect all analytes. Low recoveries for many analytes were due to matrix effects.

The precision is estimated by the RPD, which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred. The RPDs were exceeded for many analytes with concentrations near the detection limit, because this adversely impacts the reproductibility of the results. Some of the high RPDs may be attributable to sample heterogeneity problems.

In summary, the vast majority of the QC results for the core samples were within the boundaries specified in DOE (1995). The discrepancies mentioned here and footnoted in the data summary tables should not impact either the validity or the use of the data.

B3.2.2 Quality Control Assessment for the 1994 Vapor Sampling Event

The QC assessment for vapor samples is specified in the governing document by Burnum (1995). The document states that the relative standard deviation (RSD) must be less than 25 percent. The RSD is a measure of variability defined as the standard deviation divided by the mean, times one hundred.

Positive identification of organic analytes involves matching the gas chromatograph (GC) retention times and mass spectrometer (MS) data from a sample with that obtained from analysis of standards. The concentration of an analyte in the sample is said to be quantitatively measured if the response of the GC/MS has been established at several known concentrations of that analyte (the GC/MS has been calibrated for that analyte), and the MS response to the analyte in the sample is between the lowest and highest responses to the known concentrations (the analyte is within the calibration range). In this QC summary, only those detected gases that were defined as inorganic or those organic gases defined as quantitatively measured or positively identified will be assessed (Huckaby and Bratzel 1995).

Seven inorganic gases were detected, and all of them met the QC criteria. Two organic gases analyzed in SUMMA™ samples were defined as quantitatively measured, and all of them met the criteria. Seventeen organic analytes were positively identified, but the results cannot be considered quantitative, and thus may not be accurate to within the ≤ 25 percent criteria established by Burnum (1995). Fifteen of these gases were analyzed within their holding times, and of these only three met the QC criteria. The other two organic gases that were positively identified exceeded their holding times and the QC criteria (Huckaby and Bratzel 1995).

B3.3 DATA CONSISTENCY CHECKS

Comparisons of different analytical methods can help to assess the consistency and quality of the data. Several comparisons were possible with the data set provided by the core samples. Comparisons were made between total alpha and the sum of the alpha emitters, total beta and the sum of the beta emitters, and phosphorus by ICP and phosphate by IC. No comparisons were possible for sulfur and sulfate data. In addition, mass and charge balances were calculated to help assess the overall data consistency.

B3.3.1 Comparison of Results from Different Analytical Methods

The following data consistency checks compare the results from two different analytical methods. Close comparisons between the two methods strengthens the credibility of both results, whereas poor comparisons brings the reliability of the data into question. All analytical mean results were taken from the core composite data presented in Table B3-5.

The analytical phosphorus mean of samples prepared by fusion digestion and analyzed by ICP was 18,200 μg/g, which represents total phosphorus. This amount of phosphorus converts to 55,700 μg/g of phosphate. In a check of soluble phosphate, samples prepared by water digestion and analyzed by ICP produced a phosphorus mean of 6,610 μg/g, which converts to 20,200 μg/g of phosphate. The ICP result agrees well with the IC phosphate result of 20,500 μg/g, and 36.8 percent appears to be present in a soluble form.

Total alpha and total beta were compared to the sum of the alpha and beta emitters in Table B3-1. As shown in the table, the sum of all analyzed alpha emitters accounts for 125 percent of the total alpha result, while the sum of beta emitters accounts for 111 percent of the total beta result. This degree of consistency suggests reasonable agreement of the data between the separate methods. Note that the ^{90}Sr activity must be multiplied by 2 to account for the activity of its daughter product, ^{90}Y.

Table B3-1. Comparison of Alpha and Beta Emitters with Total Alpha and Total Beta Core Composite Results.

Analytes for Alpha Comparison	**Mean**	**Analytes for Beta Comparison**	**Mean**
	μCi/g		**μCi/g**
^{241}Am	0.154	^{137}Cs	820
Total Pu	0.341	2 x ^{90}Sr	1,534
Sum of alpha emitters	0.495	Sum of beta emitters	2,354
Total alpha activity	0.395	Total beta activity	2,120
RPD	22.5%	RPD	10.5%
Sum of beta emitters as a percent of the total	125%	Sum of beta emitters as a percent of the total	111%

There are discrepancies in the results between both sets of methods. Total alpha results were difficult to obtain because of interference from the high salts resulting from the fusion preparation. Therefore, small sample sizes were used to minimize the amount of salts on the mount. Normally, plutonium and americium account for >95 percent of the total alpha results. The results appear to show a lower total alpha concentration than the sum of the representative isotopes ($^{239/240}$Pu and ^{241}Am).

The higher total alpha concentration may be due to: 1) high counting error; 2) interference from ^{137}Cs and ^{90}Sr/^{90}Y present in the samples (the total beta activity present was 5,000 times greater than total alpha for these samples). A small amount of the β-emissions may have confounded the detector (the activity of the samples is so low that the offset used to discriminate between alpha and beta plateaus was not sufficient to provide accurate readings). This particular issue of interference between alpha and beta emitters has since been resolved.

B3.3.2 Mass and Charge Balances

The principal objective in performing mass and charge balances is to determine if the measurements are consistent. In calculating the balances, only analytes from the core composite data listed in Section B3.4 detected at a concentration of 2,000 μg/g or greater were considered. In the case of multiple ICP digestions for a given analyte, the method which produced the largest result was used. Analytes such as phosphate, carbonate, and silicate were combined with cations to form precipitates. Other analytes were assumed to be present in their common hydroxide form.

The mass balance was calculated from the formula below. The factor of 0.0001 is the conversion factor from μg/g to weight percent.

Mass balance = Percent water + 0.0001 x {Total Analyte Concentration}
= Percent water + 0.0001 x $\{Ca_3(PO_4)_2 + Ca(OH)_2 + FeSiO_3 + Al(OH)_3 + Pb(OH)_2 + Na_3PO_4 + Na_2CO_3 + Ni(OH)_2 + UO_3 + Na^+ + NO_2^- + NO_3^- + PO_4^{3-} + SO_4^{2-} + CO_3^{2-} + C_2H_3O_2^-\}$

The total analyte concentrations from the above equation is 613,000 μg/g. The mean weight percent water obtained from thermogravimetric analysis was 35.7 percent, or 357,000 μg/g. The mass balance resulting from adding the percent water to the total analyte concentration is 97.0 percent (Table B3-4).

The following equations demonstrate the derivation of total cations and total anions, and the charge balance is the ratio of these two values. When performing the charge balance, the uncombined (or free) concentration was used in the calculation. To derive the results as shown in the equations, all concentrations must first be converted to a μg/g basis.

Total cations (μeq/g) = $[Na^+]/23.0$ = 3,060 μeq/g
Total anions (μeq/g) = $[NO_2^-]/46.0 + [NO_3^-]/62.0 + [PO_4^{3-}]/31.7 + [SO_4^{2-}]/48.0 + [C_2H_3O_2^-]/59.0 + [CO_3^{2-}]/30.0$ = 3,061 μeq/g

The net charge was 1 microequivalent. The charge balance obtained by dividing the sum of the positive charge by the sum of the negative charge was 1.00.

Table B3-2. Cation Mass and Charge Data. (2 sheets)

Analyte	Concentration	Assumed Species	Concentration of Assumed Species	Charge
	μg/g		μg/g	μeq/g
Aluminum	84,200	$Al(OH)_3$	243,000	0
Calcium	19,100	$Ca_3(PO_4)_2$	49,300	0
Iron	18,700	$Fe(OH)_2$	22,100	0
		$FeSiO_3$	11,700	0

Table B3-2. Cation Mass and Charge Data. (2 sheets)

Analyte	Concentration µg/g	Assumed Species	Concentration of Assumed Species µg/g	Charge µeq/g
Lead	3,360	$Pb(OH)_2$	3,910	0
Nickel	14,000	$Ni(OH)_2$	22,100	0
Phosphorus	18,300	Na_3PO_4		
		$Ca_3(PO_4)_2$		

Table B3-2. Cation Mass and Charge Data. (2 sheets)

Analyte	Concentration µg/g	Assumed Species	Concentration of Assumed Species µg/g	Charge µeq/g
Sodium	88,000	Na^+	70,400	3,060
		Na_3PO_4	9,150	0
		Na_2CO_3	31,700	0
Silicon	6,740	SiO_3^{-2}		
Uranium	12,900	UO_3	15,500	0
Total			479,000	3,060

Table B3-3. Anion Mass and Charge Data.

Analyte	Concentration µg/g	Assumed Species	Assumed Species Concentration µg/g	Charge µeq/g
Nitrite	40,800	NO_2^-	40,800	887
Nitrate	40,300	NO_3^-	40,300	650
Phosphate	20,500	PO_4^{3-}	20,500	647
Sulfate	7,700	SO_4^{-2}	7,700	160
TIC	5,450	CO_3^{-2}	18,000	598
TOC	2,850	$C_2H_3O_2^-$	7,010	119
Total			134,000	3,061

Table B3-4. Mass Balance Totals.

Totals	Concentrations µg/g	Charges µeq/g
Total from Table B3-2	479,000	3,060
Total from Table B3-3	134,000	-3,061
Percent water	357,000	0
Grand Total	970,000	net charge = (1)

In summary, the above calculations yield very good mass and charge balance values (1.00 for charge balance, almost no net charge, and 97.0 percent for mass balance), indicating that the analytical results are consistent.

B3.4 DATA ANALYSIS

The following evaluation was performed on the analytical data from the samples from tank 241-C-109.

Because an inventory estimate is needed without comparing it to a threshold value, two-sided 95 percent confidence intervals on the mean inventory are computed. This was done with both the composite-level and segment-level data.

The lower and upper limits (LL and UL) to a two-sided 95 percent confidence interval for the mean are

$$\hat{\mu} \pm t_{(df,0.025)} \times \hat{\sigma}_{\hat{\mu}}.$$

In these equations, $\hat{\mu}$ is the estimate of the mean concentration, $\hat{\sigma}_{\hat{\mu}}$ is the estimate of the standard deviation of the mean concentration, and $t_{(df,0.025)}$ is the quantile from Student's t distribution with df degrees of freedom for a two-sided 95 percent confidence interval.

The mean, $\hat{\mu}$, and the standard deviation, $\hat{\sigma}_{\hat{\mu}}$, were estimated using restricted maximum likelihood estimation (REML) methods. The degrees of freedom (df), for tank 241-C-109, is the number of cores sampled minus one.

B3.4.1 Composite and Subsegment Means

The statistics in this section were based on analytical data from the most recent sampling event of tank 241-C-109. Analysis of variance (ANOVA) techniques were used to estimate the mean, and calculate confidence limits on the mean, for all analytes that had at least 50 percent of reported values above the detection limit. If at least 50 percent of the reported values were above the detection limit, all of the data was used in the computations. The detection limit was used as the value for nondetected results. No ANOVA estimates were computed for analytes with less than 50 percent detected values. Only arithmetic means were computed for these analytes.

The results given below are ANOVA estimates based on the core composite data from core 47, core 48, and core 49 for tank 241-C-109. Estimates of the mean concentration, and confidence interval on the mean concentration, are given in Table B3-4. The lower limit, LL, to a 95 percent confidence interval can be negative. Because an actual concentration of less than zero is not possible, the lower limit is reported as zero, whenever this occurred.

Table B3-5. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
pH	pH	1.01E+01	4.00E-01	2	8.34E+00	1.18E+01
Pu-238	%	1.00E-02	2.65E-03	2	0.00E+00	2.14E-02
Pu-239	%	9.53E+01	1.28E+00	2	8.98E+01	1.01E+02
Pu-240	%	4.60E+00	1.26E+00	2	0.00E+00	1.00E+01
Pu-241	%	8.99E-02	2.69E-02	2	0.00E+00	2.06E-01
Pu-242	%	2.48E-02	4.42E-03	2	5.82E-03	4.38E-02
U-234	%	5.70E-03	2.02E-04	2	4.83E-03	6.57E-03
U-235	%	6.56E-01	1.73E-02	2	5.81E-01	7.30E-01
U-236	%	8.05E-03	1.44E-03	2	1.86E-03	1.42E-02
U-238	%	9.93E+01	6.65E-03	2	9.93E+01	9.93E+01
Wt.%.Solids	%	6.43E+01	1.12E+01	2	1.63E+01	1.00E+02
Mass Loss - total	%	3.97E+01	6.30E+00	1	0.00E+00	1.00E+02
Mass Loss - transition 1	%	2.07E+01	5.88E+00	1	0.00E+00	9.53E+01
Am-241.f.Alpha	µCi/g	1.54E-01	9.01E-02	2	0.00E+00	5.42E-01
Am-241.f.GEA[1]	µCi/g	<5.45E-01	n/a	n/a	n/a	n/a
Am-241.w.GEA[1]	µCi/g	<3.48E-03	n/a	n/a	n/a	n/a
C-14[2]	µCi/g	1.97E-05	8.66E-06	2	0.00E+00	5.70E-05
Cs-137.f.GEA	µCi/g	8.20E+02	1.40E+02	2	2.20E+02	1.42E+03
Cs-137.w.GEA	µCi/g	7.95E+00	1.33E+00	2	2.21E+00	1.37E+01
Co-60.f.GEA[1]	µCi/g	<2.13E-02	n/a	n/a	n/a	n/a
Co-60.w.GEA	µCi/g	7.81E-04	1.24E-04	2	2.49E-04	1.31E-03
Eu-154.f.GEA[1]	µCi/g	<2.26E-01	n/a	n/a	n/a	n/a
Eu-154.w.GEA[1]	µCi/g	<1.44E-03	n/a	n/a	n/a	n/a
Eu-155.f.GEA[1]	µCi/g	<8.43E-01	n/a	n/a	n/a	n/a
Eu-155.w.GEA[1]	µCi/g	<7.17E-03	n/a	n/a	n/a	n/a
Alpha.f	µCi/g	3.95E-01	2.99E-01	2	0.00E+00	1.68E+00
Alpha.w	µCi/g	1.86E-03	1.49E-03	2	0.00E+00	8.28E-03
Beta.f	µCi/g	2.12E+03	4.25E+02	2	2.85E+02	3.95E+03
Beta.w	µCi/g	1.16E+01	2.90E+00	2	0.00E+00	2.40E+01
Np-237	µCi/g	3.33E-04	2.68E-05	2	2.18E-04	4.48E-04

Table B3-5. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
Pu239	µCi/g	3.19E-01	2.49E-01	2	0.00E+00	1.39E+00
Se-79[1]	µCi/g	<6.17E-05	n/a	n/a	n/a	n/a
Sr-90	µCi/g	7.66E+02	2.96E+02	2	0.00E+00	2.04E+03
Tc-99	µCi/g	1.06E-01	6.19E-03	2	7.93E-02	1.33E-01
Total alpha from Pu	µCi/g	3.41E-01	2.68E-01	2	0.00E+00	1.49E+00
Tritium	µCi/g	7.10E-03	7.07E-04	2	4.06E-03	1.01E-02
ICP.a.Al	µg/g	5.43E+04	2.42E+04	2	0.00E+00	1.58E+05
ICP.f.Al	µg/g	8.42E+04	3.79E+04	2	0.00E+00	2.47E+05
ICP.w.Al	µg/g	2.09E+02	1.02E+02	2	0.00E+00	6.46E+02
Antimony(AA:A)[1]	µg/g	<2.22E+00	n/a	n/a	n/a	n/a
ICP.a.Sb	µg/g	4.30E+01	8.43E+00	2	6.72E+00	7.93E+01
ICP.f.Sb[1]	µg/g	<1.48E+02	n/a	n/a	n/a	n/a
ICP.w.Sb[1]	µg/g	<1.17E+01	n/a	n/a	n/a	n/a
Ammonia (N)	µg/g	5.30E+01	5.11E+00	2	3.10E+01	7.50E+01
Arsenic(AA:A)	µg/g	6.56E+01	3.33E+01	2	0.00E+00	2.09E+02
ICP.a.As[1]	µg/g	<2.11E+01	n/a	n/a	n/a	n/a
ICP.f.As[1]	µg/g	<3.17E+02	n/a	n/a	n/a	n/a
ICP.w.As[1]	µg/g	<2.49E+01	n/a	n/a	n/a	n/a
ICP.a.Ba	µg/g	4.53E+01	8.84E+00	2	7.31E+00	8.34E+01
ICP.f.Ba	µg/g	6.82E+01	1.36E+01	2	9.64E+00	1.27E+02
ICP.w.Ba[1]	µg/g	<1.96E+00	n/a	n/a	n/a	n/a
ICP.a.Be[1]	µg/g	<6.66E-01	n/a	n/a	n/a	n/a
ICP.f.Be[1]	µg/g	<9.99E+00	n/a	n/a	n/a	n/a
ICP.w.Be[1]	µg/g	<7.79E-01	n/a	n/a	n/a	n/a
ICP.a.B	µg/g	1.06E+02	2.53E+01	2	0.00E+00	2.15E+02
ICP.f.B[1]	µg/g	<1.86E+02	n/a	n/a	n/a	n/a
ICP.w.B	µg/g	4.28E+01	2.21E+01	2	0.00E+00	1.38E+02
ICP.a.Cd	µg/g	9.50E+00	1.26E+00	2	4.09E+00	1.49E+01
ICP.f.Cd[1]	µg/g	<2.34E+01	n/a	n/a	n/a	n/a
ICP.w.Cd[1]	µg/g	<1.84E+00	n/a	n/a	n/a	n/a

Table B3-5. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.a.Ca	µg/g	1.50E+04	2.53E+03	2	4.08E+03	2.58E+04
ICP.f.Ca	µg/g	1.91E+04	2.91E+03	2	6.51E+03	3.16E+04
ICP.w.Ca	µg/g	1.07E+02	3.87E+01	2	0.00E+00	2.73E+02
ICP.a.Ce[2]	µg/g	4.66E+01	1.52E+01	2	0.00E+00	1.12E+02
ICP.f.Ce[1]	µg/g	<3.18E+02	n/a	n/a	n/a	n/a
ICP.w.Ce[1]	µg/g	<2.50E+01	n/a	n/a	n/a	n/a
Chloride	µg/g	7.33E+02	3.33E+01	2	5.90E+02	8.77E+02
ICP.a.Cr	µg/g	2.05E+02	1.20E+01	2	1.53E+02	2.56E+02
ICP.f.Cr	µg/g	2.50E+02	1.71E+01	2	1.76E+02	3.24E+02
ICP.w.Cr	µg/g	1.92E+02	1.68E+01	2	1.20E+02	2.64E+02
ICP.a.Co[2]	µg/g	4.92E+01	5.56E+00	2	2.53E+01	7.31E+01
ICP.f.Co[1]	µg/g	<5.83E+02	n/a	n/a	n/a	n/a
ICP.w.Co[1]	µg/g	<4.58E+01	n/a	n/a	n/a	n/a
ICP.a.Cu	µg/g	3.50E+01	1.23E+01	2	0.00E+00	8.79E+01
ICP.f.Cu	µg/g	6.28E+01	1.15E+01	2	1.34E+01	1.12E+02
ICP.w.Cu[1]	µg/g	<2.17E+00	n/a	n/a	n/a	n/a
Cyanide	µg/g	8.49E-01	2.93E-01	2	0.00E+00	2.11E+00
Cyanide(IC:W)	µg/g	8.80E+02	2.12E+02	2	0.00E+00	1.79E+03
ICP.a.Dy[2]	µg/g	1.69E+00	3.26E-01	2	2.84E-01	3.09E+00
ICP.f.Dy[1]	µg/g	<1.66E+01	n/a	n/a	n/a	n/a
ICP.w.Dy[1]	µg/g	<1.30E+00	n/a	n/a	n/a	n/a
Fluoride	µg/g	7.00E+02	3.00E+02	2	0.00E+00	1.99E+03
Cr(VI)	µg/g	4.27E+01	4.48E+00	2	2.34E+01	6.20E+01
ICP.a.Fe	µg/g	1.87E+04	6.30E+03	2	0.00E+00	4.58E+04
ICP.f.Fe	µg/g	1.77E+04	4.30E+03	2	0.00E+00	3.62E+04
ICP.w.Fe	µg/g	9.78E+02	8.16E+01	2	6.27E+02	1.33E+03
ICP.a.La	µg/g	4.40E+01	2.15E+01	2	0.00E+00	1.37E+02
ICP.f.La[1]	µg/g	<3.87E+01	n/a	n/a	n/a	n/a
ICP.w.La[1]	µg/g	<3.04E+00	n/a	n/a	n/a	n/a
ICP.a.Pb	µg/g	3.36E+03	2.62E+03	2	0.00E+00	1.47E+04

Table B3-5. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.f.Pb	μg/g	2.94E+03	2.17E+03	2	0.00E+00	1.23E+04
ICP.w.Pb[1]	μg/g	<2.94E+01	n/a	n/a	n/a	n/a
ICP.a.Li	μg/g	5.17E+00	1.96E+00	2	0.00E+00	1.36E+01
ICP.f.Li[1]	μg/g	<2.31E+01	n/a	n/a	n/a	n/a
ICP.w.Li[1]	μg/g	<1.82E+00	n/a	n/a	n/a	n/a
ICP.a.Mg	μg/g	4.26E+02	6.60E+01	2	1.42E+02	7.09E+02
ICP.f.Mg	μg/g	5.51E+02	1.05E+02	2	9.78E+01	1.00E+03
ICP.w.Mg	μg/g	7.00E+00	5.77E-01	2	4.52E+00	9.48E+00
ICP.a.Mn	μg/g	9.27E+01	2.49E+01	2	0.00E+00	2.00E+02
ICP.f.Mn	μg/g	1.28E+02	2.14E+01	2	3.56E+01	2.19E+02
ICP.w.Mn[1]	μg/g	<2.16E-01	n/a	n/a	n/a	n/a
Hg(CVAA)	μg/g	7.35E+00	7.51E-01	2	4.12E+00	1.06E+01
ICP.a.Mo	μg/g	3.80E+01	3.61E+00	2	2.25E+01	5.35E+01
ICP.f.Mo[1]	μg/g	<4.21E+01	n/a	n/a	n/a	n/a
ICP.w.Mo	μg/g	2.60E+01	2.02E+00	2	1.73E+01	3.47E+01
ICP.a.Nd	μg/g	8.42E+01	2.48E+01	2	0.00E+00	1.91E+02
ICP.f.Nd[1]	μg/g	<1.55E+02	n/a	n/a	n/a	n/a
ICP.w.Nd[1]	μg/g	<1.22E+01	n/a	n/a	n/a	n/a
ICP.a.Ni	μg/g	1.40E+04	1.11E+03	2	9.24E+03	1.88E+04
ICP.w.Ni	μg/g	6.95E+01	2.82E+01	2	0.00E+00	1.91E+02
Nitrate	μg/g	4.03E+04	3.84E+03	2	2.38E+04	5.69E+04
Nitrite	μg/g	4.08E+04	2.09E+03	2	3.18E+04	4.98E+04
Phosphate	μg/g	2.05E+04	4.10E+03	2	2.86E+03	3.81E+04
ICP.a.P	μg/g	1.83E+04	2.14E+03	2	9.08E+03	2.75E+04
ICP.f.P	μg/g	1.82E+04	1.84E+03	2	1.03E+04	2.61E+04
ICP.w.P	μg/g	6.61E+03	1.32E+03	2	9.37E+02	1.23E+04
ICP.a.K	μg/g	5.44E+02	6.98E+01	2	2.43E+02	8.44E+02
ICP.w.K	μg/g	5.13E+02	3.34E+01	2	3.70E+02	6.57E+02
ICP.a.Re	μg/g	7.33E+00	1.09E+00	2	2.63E+00	1.20E+01
ICP.f.Re[1]	μg/g	<5.40E+01	n/a	n/a	n/a	n/a

Table B3-5. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.w.Re[1]	μg/g	<4.25E+00	n/a	n/a	n/a	n/a
ICP.a.Rh[1]	μg/g	<1.71E+01	n/a	n/a	n/a	n/a
ICP.f.Rh[1]	μg/g	<2.56E+02	n/a	n/a	n/a	n/a
ICP.w.Rh[1]	μg/g	<2.02E+01	n/a	n/a	n/a	n/a
ICP.a.Ru[1]	μg/g	<7.85E+00	n/a	n/a	n/a	n/a
ICP.f.Ru[1]	μg/g	<1.09E+02	n/a	n/a	n/a	n/a
ICP.w.Ru[1]	μg/g	<8.59E+00	n/a	n/a	n/a	n/a
Selenium (AA:A)[1]	μg/g	<2.38E+00	n/a	n/a	n/a	n/a
ICP.a.Se[1]	μg/g	<3.15E+01	n/a	n/a	n/a	n/a
ICP.f.Se[1]	μg/g	<4.73E+02	n/a	n/a	n/a	n/a
ICP.w.Se[1]	μg/g	<3.72E+01	n/a	n/a	n/a	n/a
ICP.a.Si	μg/g	1.54E+03	1.86E+02	2	7.37E+02	2.34E+03
ICP.f.Si	μg/g	6.74E+03	4.50E+03	2	0.00E+00	2.61E+04
ICP.w.Si	μg/g	1.28E+02	3.71E+01	2	0.00E+00	2.88E+02
ICP.a.Ag[1]	μg/g	<1.62E+00	n/a	n/a	n/a	n/a
ICP.f.Ag[1]	μg/g	<2.44E+01	n/a	n/a	n/a	n/a
ICP.w.Ag[1]	μg/g	<1.91E+00	n/a	n/a	n/a	n/a
ICP.a.Na	μg/g	8.36E+04	4.47E+03	2	6.43E+04	1.03E+05
ICP.f.Na	μg/g	8.80E+04	6.82E+03	2	5.86E+04	1.17E+05
ICP.w.Na	μg/g	7.04E+04	6.95E+03	2	4.05E+04	1.00E+05
ICP.a.Sr	μg/g	2.63E+02	9.15E+01	2	0.00E+00	6.56E+02
ICP.f.Sr	μg/g	3.77E+02	1.92E+02	2	0.00E+00	1.20E+03
ICP.w.Sr	μg/g	8.33E-01	1.67E-01	2	1.16E-01	1.55E+00
Sulfate	μg/g	7.70E+03	8.05E+02	2	4.24E+03	1.12E+04
ICP.a.Te[2]	μg/g	5.75E+01	1.90E+01	2	0.00E+00	1.39E+02
ICP.f.Te[1]	μg/g	<2.97E+02	n/a	n/a	n/a	n/a
ICP.w.Te[1]	μg/g	<2.33E+01	n/a	n/a	n/a	n/a
ICP.a.Tl[1]	μg/g	<1.14E+02	n/a	n/a	n/a	n/a
ICP.f.Tl[1]	μg/g	<1.72E+03	n/a	n/a	n/a	n/a
ICP.w.Tl[1]	μg/g	<1.35E+02	n/a	n/a	n/a	n/a

Table B3-5. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.a.Th	µg/g	4.52E+01	1.27E+01	2	0.00E+00	9.99E+01
ICP.f.Th[1]	µg/g	<2.29E+02	n/a	n/a	n/a	n/a
ICP.w.Th[1]	µg/g	<1.80E+01	n/a	n/a	n/a	n/a
ICP.a.Ti	µg/g	2.52E+01	1.72E+01	2	0.00E+00	9.93E+01
ICP.f.Ti[2]	µg/g	1.10E+02	9.53E+01	2	0.00E+00	5.20E+02
ICP.w.Ti[1]	µg/g	<1.32E+00	n/a	n/a	n/a	n/a
TC(Persulfate)	µg/g	8.30E+03	3.33E+02	2	6.87E+03	9.73E+03
TC(TIC/TOC/TC)	µg/g	7.83E+03	5.80E+02	2	5.33E+03	1.03E+04
TIC(Persulfate)	µg/g	5.45E+03	1.89E+02	2	4.64E+03	6.26E+03
TIC(TIC/TOC/TC)	µg/g	5.26E+03	4.20E+02	2	3.45E+03	7.06E+03
TOC(Persulfate)[3]	µg/g	2.85E+03	2.08E+02	2	1.95E+03	3.75E+03
TOC(TIC/TOC/TC)[3]	µg/g	2.57E+03	2.55E+02	2	1.47E+03	3.67E+03
ICP.a.U	µg/g	1.07E+04	2.54E+03	2	0.00E+00	2.16E+04
ICP.f.U	µg/g	1.29E+04	6.07E+03	2	0.00E+00	3.90E+04
ICP.w.U[1]	µg/g	<1.36E+02	n/a	n/a	n/a	n/a
Uranium	µg/g	1.57E+01	6.07E+00	2	0.00E+00	4.18E+01
ICP.a.V	µg/g	8.50E+00	2.78E+00	2	0.00E+00	2.05E+01
ICP.f.V[1]	µg/g	<2.81E+01	n/a	n/a	n/a	n/a
ICP.w.V[1]	µg/g	<2.18E+00	n/a	n/a	n/a	n/a
ICP.a.Zn	µg/g	2.43E+02	2.47E+01	2	1.37E+02	3.50E+02
ICP.f.Zn	µg/g	3.61E+02	1.37E+01	2	3.02E+02	4.20E+02
ICP.w.Zn	µg/g	8.17E+00	6.01E-01	2	5.58E+00	1.08E+01
ICP.a.Zr[2]	µg/g	4.75E+00	1.38E+00	2	0.00E+00	1.07E+01
ICP.f.Zr[1]	µg/g	<2.37E+01	n/a	n/a	n/a	n/a
ICP.w.Zr[1]	µg/g	<1.86E+00	n/a	n/a	n/a	n/a

Notes:

n/a = not applicable

[1]More than 50 percent of the analytical results were less than values; therefore, confidence intervals were not computed.

[2]Some "less-than" values are in the analytical results.

[3]Wet Basis

In addition to core composite data, subsegment level data from tank 241-C-109 was also available from core 47, core 48, and core 49. Mean concentration estimates, along with 95 percent confidence intervals on the mean, are given in Table B3-5 for the subsegment sample data.

Table B3-6. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Subsegment Sample Data. (4 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
pH	pH	1.01E+01	3.23E-01	2	8.75E+00	1.15E+01
Mass Loss - total	%	3.93E+01	3.97E+00	2	2.22E+01	5.64E+01
Mass Loss - transition 1	%	2.49E+01	7.54E+00	2	0.00E+00	5.73E+01
Wt.%.solids	%	6.26E+01	6.98E+00	2	3.25E+01	9.26E+01
Am-241.f.GEA[1]	μCi/g	<4.91E-01	n/a	n/a	n/a	n/a
Cs-137.a.GEA	μCi/g	2.16E+01	9.78E+00	1	0.00E+00	1.46E+02
Cs-137.f.GEA	μCi/g	7.33E+02	2.20E+02	2	0.00E+00	1.68E+03
Co-60.f.GEA[1]	μCi/g	< 1.66E-02	n/a	n/a	n/a	n/a
Eu-154.f.GEA[1]	μCi/g	<2.72E-01	n/a	n/a	n/a	n/a
Eu-155.f.GEA[1]	μCi/g	<8.76E-01	n/a	n/a	n/a	n/a
Alpha.a	μCi/g	5.30E-02	4.96E-03	1	0.00E+00	1.16E-01
Sr-90.f.Beta	μCi/g	1.04E+03	5.71E+02	2	0.00E+00	3.49E+03
ICP.a.Al	μg/g	2.62E+04	1.75E+04	1	0.00E+00	2.48E+05
ICP.f.Al	μg/g	7.66E+04	3.16E+04	2	0.00E+00	2.13E+05
ICP.a.Sb	μg/g	3.89E+01	2.38E+00	1	8.70E+00	6.91E+01
ICP.f.Sb[1]	μg/g	< 1.18E+02	n/a	n/a	n/a	n/a
ICP.a.As[1]	μg/g	<2.01E+01	n/a	n/a	n/a	n/a
ICP.f.As[1]	μg/g	<2.52E+02	n/a	n/a	n/a	n/a
ICP.a.Ba	μg/g	3.96E+01	7.13E+00	1	0.00E+00	1.30E+02
ICP.f.Ba	μg/g	6.50E+01	7.42E+00	2	3.30E+01	9.69E+01
ICP.a.Be[1]	μg/g	<6.33E-01	n/a	n/a	n/a	n/a
ICP.f.Be[1]	μg/g	<7.96E+00	n/a	n/a	n/a	n/a
ICP.a.B	μg/g	7.20E+01	1.33E+01	1	0.00E+00	2.40E+02
ICP.f.B[1]	μg/g	< 1.48E+02	n/a	n/a	n/a	n/a
ICP.a.Cd	μg/g	6.75E+00	5.00E-01	1	3.97E-01	1.31E+01
ICP.f.Cd[1]	μg/g	< 1.87E+01	n/a	n/a	n/a	n/a

Table B3-6. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Subsegment Sample Data. (4 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.a.Ca	μg/g	1.65E+04	9.00E+02	1	5.06E+03	2.79E+04
ICP.f.Ca	μg/g	1.85E+04	2.96E+03	2	5.74E+03	3.13E+04
ICP.a.Ce[1]	μg/g	<2.02E+01	n/a	n/a	n/a	n/a
ICP.f.Ce[1]	μg/g	<2.54E+02	n/a	n/a	n/a	n/a
Chloride	μg/g	7.74E+02	9.43E+01	2	3.68E+02	1.18E+03
ICP.a.Cr	μg/g	2.08E+02	1.16E+01	1	5.99E+01	3.55E+02
ICP.f.Cr	μg/g	2.58E+02	3.78E+01	2	9.55E+01	4.21E+02
ICP.a.Co[1]	μg/g	<3.69E+01	n/a	n/a	n/a	n/a
ICP.f.Co[1]	μg/g	<4.64E+02	n/a	n/a	n/a	n/a
ICP.a.Cu	μg/g	1.41E+01	6.25E-01	1	6.18E+00	2.21E+01
ICP.f.Cu	μg/g	1.28E+02	1.74E+01	2	5.32E+01	2.03E+02
Cyanide	μg/g	6.61E-01	1.64E-01	2	0.00E+00	1.37E+00
Cyanide(IC:W)	μg/g	9.16E+02	2.53E+02	2	0.00E+00	2.01E+03
ICP.a.Dy[1]	μg/g	< 1.05E+00	n/a	n/a	n/a	n/a
ICP.f.Dy[1]	μg/g	< 1.32E+01	n/a	n/a	n/a	n/a
Fluoride[2]	μg/g	4.64E+02	9.40E+01	2	5.99E+01	8.69E+02
ICP.a.Fe	μg/g	1.41E+04	3.94E+03	1	0.00E+00	6.41E+04
ICP.f.Fe	μg/g	2.20E+04	6.83E+03	2	0.00E+00	5.14E+04
ICP.a.La	μg/g	7.88E+00	8.75E-01	1	0.00E+00	1.90E+01
ICP.f.La[1]	μg/g	<4.80E+01	n/a	n/a	n/a	n/a
ICP.a.Pb	μg/g	6.04E+02	3.42E+01	1	1.69E+02	1.04E+03
ICP.f.Pb	μg/g	3.14E+03	2.25E+03	2	0.00E+00	1.28E+04
ICP.a.Li	μg/g	4.87E+00	8.75E-01	1	0.00E+00	1.60E+01
ICP.f.Li[1]	μg/g	< 1.84E+01	n/a	n/a	n/a	n/a
ICP.a.Mg	μg/g	5.17E+02	7.50E+01	1	0.00E+00	1.47E+03
ICP.f.Mg	μg/g	5.18E+02	1.04E+02	2	7.21E+01	9.64E+02
ICP.a.Mn	μg/g	6.59E+01	1.26E+01	1	0.00E+00	2.26E+02
ICP.f.Mn	μg/g	2.51E+02	4.12E+01	2	7.34E+01	4.28E+02
ICP.a.Mo	μg/g	3.23E+01	1.75E+00	1	1.00E+01	5.45E+01
ICP.f.Mo[2]	μg/g	4.21E+01	2.52E+00	2	3.12E+01	5.29E+01

Table B3-6. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Subsegment Sample Data. (4 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.a.Nd	μg/g	3.36E+01	2.63E+00	1	1.85E-01	6.71E+01
ICP.f.Nd[1]	μg/g	< 1.25E+02	n/a	n/a	n/a	n/a
ICP.a.Ni	μg/g	1.56E+04	1.79E+03	1	0.00E+00	3.83E+04
Nitrate	μg/g	4.16E+04	6.33E+03	2	1.44E+04	6.88E+04
Nitrite	μg/g	4.06E+04	4.44E+03	2	2.15E+04	5.97E+04
Phosphate	μg/g	1.91E+04	5.15E+03	2	0.00E+00	4.13E+04
ICP.a.P	μg/g	2.37E+04	2.16E+03	1	0.00E+00	5.11E+04
ICP.f.P	μg/g	1.63E+04	3.10E+03	2	2.95E+03	2.96E+04
ICP.a.K	μg/g	5.37E+02	7.22E+01	1	0.00E+00	1.46E+03
ICP.a.Re	μg/g	6.50E+00	1.00E+00	1	0.00E+00	1.92E+01
ICP.f.Re[1]	μg/g	<4.30E+01	n/a	n/a	n/a	n/a
ICP.a.Rh[1]	μg/g	< 1.62E+01	n/a	n/a	n/a	n/a
ICP.f.Rh[1]	μg/g	<2.04E+02	n/a	n/a	n/a	n/a
ICP.a.Ru[1]	μg/g	<6.92E+00	n/a	n/a	n/a	n/a
ICP.f.Ru[1]	μg/g	<8.71E+01	n/a	n/a	n/a	n/a
ICP.f.Se[1]	μg/g	<3.77E+02	n/a	n/a	n/a	n/a
ICP.a.Si	μg/g	8.67E+02	1.73E+02	1	0.00E+00	3.07E+03
ICP.f.Si	μg/g	6.80E+03	4.58E+03	2	0.00E+00	2.65E+04
ICP.a.Ag[1]	μg/g	< 1.54E+00	n/a	n/a	n/a	n/a
ICP.f.Ag[1]	μg/g	< 1.94E+01	n/a	n/a	n/a	n/a
ICP.a.Na	μg/g	1.02E+05	8.95E+03	1	0.00E+00	2.15E+05
ICP.f.Na	μg/g	8.07E+04	1.25E+04	2	2.68E+04	1.35E+05
ICP.a.Sr	μg/g	3.97E+02	5.10E+01	1	0.00E+00	1.05E+03
ICP.f.Sr	μg/g	2.95E+02	1.13E+02	2	0.00E+00	7.82E+02
Sulfate	μg/g	7.92E+03	1.23E+03	2	2.64E+03	1.32E+04
ICP.a.Te[2]	μg/g	3.00E+01	1.10E+01	1	0.00E+00	1.70E+02
ICP.f.Te[1]	μg/g	<2.36E+02	n/a	n/a	n/a	n/a
ICP.a.Tl[1]	μg/g	< 1.09E+02	n/a	n/a	n/a	n/a
ICP.f.Tl[1]	μg/g	< 1.37E+03	n/a	n/a	n/a	n/a
ICP.a.Th[1]	μg/g	< 1.45E+01	n/a	n/a	n/a	n/a

Table B3-6. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Subsegment Sample Data. (4 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.f.Th[1]	µg/g	< 1.83E+02	n/a	n/a	n/a	n/a
ICP.a.Ti	µg/g	5.00E+00	1.75E+00	1	0.00E+00	2.72E+01
ICP.f.Ti[2]	µg/g	1.03E+02	6.96E+01	2	0.00E+00	4.03E+02
TC(Persulfate)[3]	µg/g	8.86E+03	1.18E+03	2	3.76E+03	1.40E+04
TIC(Persulfate)[3]	µg/g	6.22E+03	7.22E+02	2	3.12E+03	9.32E+03
TOC(Persulfate)[3]	µg/g	2.58E+03	4.30E+02	2	7.27E+02	4.43E+03
ICP.a.U	µg/g	1.35E+04	2.20E+03	1	0.00E+00	4.14E+04
ICP.f.U	µg/g	9.96E+03	2.54E+03	2	0.00E+00	2.09E+04
ICP.a.V	µg/g	3.00E+00	7.50E-01	1	0.00E+00	1.25E+01
ICP.f.V[1]	µg/g	<2.24E+01	n/a	n/a	n/a	n/a
ICP.a.Zn	µg/g	2.03E+02	7.69E+00	1	1.05E+02	3.01E+02
ICP.f.Zn	µg/g	3.53E+02	4.91E+01	2	1.42E+02	5.64E+02
ICP.a.Zr	µg/g	1.14E+01	1.49E+00	1	0.00E+00	3.03E+01
ICP.f.Zr[1]	µg/g	<2.05E+01	n/a	n/a	n/a	n/a

Notes:

n/a = not applicable

[1]More than 50 percent of the analytical results were less than values; therefore, confidence intervals were not computed.
[2]Some "less-than" values are in the analytical results.
[3]Wet Basis.

B3.4.2 Analysis of Variance Models

A statistical model is needed to account for the spatial and measurement variability in $\hat{\sigma}_{\hat{\mu}}$. This cannot be done using an ordinary standard deviation of the data (Snedecor and Cochran 1980).

The statistical model fit to the composite sample data is

$$Y_{ij} = \mu + C_i + A_{ij},$$

$$i=1,\ldots,a,\ j=1,\ldots,b_i,$$

where

Y_{ij}	=	laboratory results from the j^{th} duplicate from the i^{th} core in the tank
μ	=	the grand mean
C_i	=	the effect of the i^{th} core
A_{ij}	=	the effect of the j^{th} analytical result from the i^{th} core
a	=	the number of cores
b_i	=	the number of analytical results from the i^{th} core

The variable C_i is assumed to be a random effect. This variable and A_{ij} are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(C)$ and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(C)$ and $\sigma^2(A)$ were obtained using Restricted Maximum Likelihood Estimation (REML) techniques. This method, applied to variance component estimation, is described in Harville (1977). The statistical results were obtained using the statistical analysis package S-PLUS[2] (StatSci 1993).

The statistical model fit to the analyte results from acid digestion ICP, Cs-137 (from GEA), and gross alpha from the segment sample data is

$$Y_{ijk} = \mu + C_i + L_{ij} + A_{ijk},$$

$$i=1,\ldots,a,\ j=1,\ldots,b_i,\ k=1,\ldots,c_{ij},$$

where

Y_{ijk}	=	laboratory results from the k^{th} duplicate in the j^{th} location in the i^{th} core in the tank,
μ	=	the grand mean
C_i	=	the effect of the i^{th} core

[2]S-PLUS is a trademark of Statistical Sciences Incorporated, Seattle, Washington.

L_{ij} = the effect of the j^{th} location in the i^{th} core

A_{ijk} = the effect of the k^{th} analytical result in the j^{th} location in the i^{th} core

a = the number of cores

b_i = the number of locations in the i^{th} core

c_{ij} = the number of analytical results from the j^{th} location in the i^{th} core

For these analytes, only homogenization test sample data were available for analysis. Observations were only measured in segment 1, subsegment D from cores 48 and 49. The location term in the ANOVA model is referring to the effect of the two locations of the homogenization test samples taken from subsegment D (the top and bottom of subsegment D).

The variable C_i and L_{ij} are assumed to be random effects. These variables and A_{ijk} are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(C)$, $\sigma^2(L)$, and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(C)$, $\sigma^2(L)$, and $\sigma^2(A)$ were obtained using REML techniques. This method, applied to variance component estimation, is described in Harville (1977). The statistical results were obtained using statistical analysis package S-PLUS™ (StatSci 1993).

The statistical model fit to the remaining analytes from segment sample data is

$$Y_{ijk} = \mu + C_i + S_{ij} + A_{ijk},$$

$$i=1,\ldots,a,\ j=1,\ldots,b_i,\ k=1,\ldots c_{ij}$$

where

Y_{ijk} = laboratory results from the k^{th} duplicate from the j^{th} subsegment in the i^{th} core in the tank

μ = the grand mean

C_i = the effect of the i^{th} core

S_{ij} = the effect of the j^{th} subsegment from the i^{th} core

A_{ijk} = the effect of the k^{th} analytical result from the j^{th} subsegment from the i^{th} core

a = the number of cores

b_i = the number of subsegments from the i^{th} core

c_{ij} = the number of analytical results from the j^{th} subsegment from the i^{th} core

The variables C_i and S_{ij} are assumed to be a random effect. This variable and A_{ij} are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(C)$, $\sigma^2(S)$, and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(C)$, $\sigma^2(S)$, and $\sigma^2(A)$ were obtained using REML techniques. This method, applied to variance component estimation, is described in Harville (1977). The statistical results were obtained using the statistical analysis package S-PLUS™ (StatSci 1993).

B3.4.3 Inventory

After the sample means are calculated for the tank for each analyte, the sampling based inventory may be calculated. The tank volume for solids is 235 kL (Hanlon 1996). The density used for the inventory calculation is 1.23 g/mL. The inventory of each of the analytes is presented in Table B3-6 for composite sample data and Table B3-7 for solid segment sample data. No inventories were computed for liquid segment sample data because there was minimal liquid in the tank (15 kL of interstitial liquid).

Table B3-7. Analytical-Based Inventory for Composite Sample Data for Tank 241-C-109. (6 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
Wt.%.Solids	1.86E+05	4.70E+04	2.89E+05
Mass Loss - total	1.15E+05	0.00E+00	2.89E+05
Mass Loss - transition 1	5.98E+04	0.00E+00	2.76E+05
Am-241.f.Alpha	4.46E+01	0.00E+00	1.57E+02
Am-241.f.GEA	<1.58E+02	N/A	N/A
Am-241.w.GEA	<1.01E+00	N/A	N/A
C-14	5.70E-03	0.00E+00	1.65E-02
Cs-137.f.GEA	2.37E+05	6.36E+04	4.11E+05
Cs-137.w.GEA	2.30E+03	6.38E+02	3.96E+03
Co-60.f.GEA	<6.17E+00	N/A	N/A
Co-60.w.GEA	2.26E-01	7.20E-02	3.80E-01
Eu-154.f.GEA	<6.54E+01	N/A	N/A
Eu-154.w.GEA	<4.15E-01	N/A	N/A
Eu-155.f.GEA	<2.44E+02	N/A	N/A
Eu-155.w.GEA	<2.07E+00	N/A	N/A

Table B3-7. Analytical-Based Inventory for Composite Sample Data for Tank 241-C-109. (6 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
Alpha.f	1.14E+02	0.00E+00	4.86E+02
Alpha.w	5.39E-01	0.00E+00	2.39E+00
Beta.f	6.11E+05	8.24E+04	1.14E+06
Beta.w	3.34E+03	0.00E+00	6.94E+03
Np-237	9.63E-02	6.29E-02	1.30E-01
Pu-239	9.23E+01	0.00E+00	4.02E+02
Se-79	< 1.78E-02	N/A	N/A
Sr-90	2.21E+05	0.00E+00	5.90E+05
Tc-99	3.06E+01	2.29E+01	3.83E+01
Total alpha from Pu	9.86E+01	0.00E+00	4.32E+02
Tritium	2.05E+00	1.17E+00	2.93E+00
ICP.a.Al	1.57E+04	0.00E+00	4.57E+04
ICP.f.Al	2.43E+04	0.00E+00	7.15E+04
ICP.w.Al	6.04E+01	0.00E+00	1.87E+02
Antimony (AA:A)	<6.41E-01	N/A	N/A
ICP.a.Sb	1.24E+01	1.94E+00	2.29E+01
ICP.f.Sb	<4.29E+01	N/A	N/A
ICP.w.Sb	<3.38E+00	N/A	N/A
Ammonia (N)	1.53E+01	8.97E+00	2.17E+01
Arsenic (AA:A)	1.90E+01	0.00E+00	6.04E+01
ICP.a.As	<6.10E+00	N/A	N/A
ICP.f.As	<9.15E+01	N/A	N/A
ICP.w.As	<7.20E+00	N/A	N/A
ICP.a.Ba	1.31E+01	2.11E+00	2.41E+01
ICP.f.Ba	1.97E+01	2.79E+00	3.66E+01
ICP.w.Ba	<5.66E-01	N/A	N/A
ICP.a.Be	< 1.93E-01	N/A	N/A
ICP.f.Be	<2.89E+00	N/A	N/A
ICP.w.Be	<2.25E-01	N/A	N/A
ICP.a.B	3.06E+01	0.00E+00	6.20E+01
ICP.f.B	<5.38E+01	N/A	N/A

Table B3-7. Analytical-Based Inventory for Composite Sample Data for Tank 241-C-109. (6 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
ICP.w.B	1.24E+01	0.00E+00	3.99E+01
ICP.a.Cd	2.75E+00	1.18E+00	4.31E+00
ICP.f.Cd	<6.77E+00	N/A	N/A
ICP.w.Cd	<5.32E-01	N/A	N/A
ICP.a.Ca	4.32E+03	1.18E+03	7.46E+03
ICP.f.Ca	5.51E+03	1.88E+03	9.13E+03
ICP.w.Ca	3.09E+01	0.00E+00	7.90E+01
ICP.a.Ce	1.35E+01	0.00E+00	3.23E+01
ICP.f.Ce	<9.20E+01	N/A	N/A
ICP.w.Ce	<7.23E+00	N/A	N/A
Chloride	2.12E+02	1.71E+02	2.53E+02
ICP.a.Cr	5.92E+01	4.43E+01	7.41E+01
ICP.f.Cr	7.22E+01	5.09E+01	9.35E+01
ICP.w.Cr	5.55E+01	3.47E+01	7.63E+01
ICP.a.Co	1.42E+01	7.32E+00	2.11E+01
ICP.f.Co	<1.68E+02	N/A	N/A
ICP.w.Co	<1.32E+01	N/A	N/A
ICP.a.Cu	1.01E+01	0.00E+00	2.54E+01
ICP.f.Cu	1.82E+01	3.87E+00	3.25E+01
ICP.w.Cu	<6.27E-01	N/A	N/A
Cyanide	2.45E-01	0.00E+00	6.10E-01
Cyanide (IC:W)	2.54E+02	0.00E+00	5.18E+02
ICP.a.Dy	4.87E-01	8.22E-02	8.92E-01
ICP.f.Dy	<4.79E+00	N/A	N/A
ICP.w.Dy	<3.75E-01	N/A	N/A
Fluoride	2.02E+02	0.00E+00	5.75E+02
Cr (VI)	1.23E+01	6.76E+00	1.79E+01
ICP.a.Fe	5.41E+03	0.00E+00	1.32E+04
ICP.f.Fe	5.12E+03	0.00E+00	1.05E+04
ICP.w.Fe	2.83E+02	1.81E+02	3.84E+02
ICP.a.La	1.27E+01	0.00E+00	3.95E+01

Table B3-7. Analytical-Based Inventory for Composite Sample Data for Tank 241-C-109. (6 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
ICP.f.La	<1.12E+01	N/A	N/A
ICP.w.La	<8.80E-01	N/A	N/A
ICP.a.Pb	9.71E+02	0.00E+00	4.23E+03
ICP.f.Pb	8.48E+02	0.00E+00	3.55E+03
ICP.w.Pb	<8.50E+00	N/A	N/A
ICP.a.Li	1.49E+00	0.00E+00	3.94E+00
ICP.f.Li	<6.68E+00	N/A	N/A
ICP.w.Li	<5.25E-01	N/A	N/A
ICP.a.Mg	1.23E+02	4.10E+01	2.05E+02
ICP.f.Mg	1.59E+02	2.83E+01	2.90E+02
ICP.w.Mg	2.02E+00	1.31E+00	2.74E+00
ICP.a.Mn	2.68E+01	0.00E+00	5.77E+01
ICP.f.Mn	3.69E+01	1.03E+01	6.34E+01
ICP.w.Mn	<6.23E-02	N/A	N/A
Hg(CVAA)	2.12E+00	1.19E+00	3.06E+00
ICP.a.Mo	1.10E+01	6.50E+00	1.55E+01
ICP.f.Mo	<1.22E+01	N/A	N/A
ICP.w.Mo	7.52E+00	5.00E+00	1.00E+01
ICP.a.Nd	2.43E+01	0.00E+00	5.52E+01
ICP.f.Nd	<4.48E+01	N/A	N/A
ICP.w.Nd	<3.52E+00	N/A	N/A
ICP.a.Ni	4.06E+03	2.67E+03	5.44E+03
ICP.w.Ni	2.01E+01	0.00E+00	5.52E+01
Nitrate	1.17E+04	6.88E+03	1.64E+04
Nitrite	1.18E+04	9.21E+03	1.44E+04
Phosphate	5.93E+03	8.25E+02	1.10E+04
ICP.a.P	5.28E+03	2.63E+03	7.94E+03
ICP.f.P	5.27E+03	2.98E+03	7.55E+03
ICP.w.P	1.91E+03	2.71E+02	3.55E+03
ICP.a.K	1.57E+02	7.03E+01	2.44E+02
ICP.w.K	1.48E+02	1.07E+02	1.90E+02

Table B3-7. Analytical-Based Inventory for Composite Sample Data for Tank 241-C-109. (6 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
ICP.a.Re	2.12E+00	7.60E-01	3.48E+00
ICP.f.Re	<1.56E+01	N/A	N/A
ICP.w.Re	<1.23E+00	N/A	N/A
ICP.a.Rh	<4.94E+00	N/A	N/A
ICP.f.Rh	<7.41E+01	N/A	N/A
ICP.w.Rh	<5.83E+00	N/A	N/A
ICP.a.Ru	<2.27E+00	N/A	N/A
ICP.f.Ru	<3.16E+01	N/A	N/A
ICP.w.Ru	<2.48E+00	N/A	N/A
Selenium (AA:A)	<6.89E-01	N/A	N/A
ICP.a.Se	<9.12E+00	N/A	N/A
ICP.f.Se	<1.37E+02	N/A	N/A
ICP.w.Se	<1.08E+01	N/A	N/A
ICP.a.Si	4.44E+02	2.13E+02	6.75E+02
ICP.f.Si	1.95E+03	0.00E+00	7.55E+03
ICP.w.Si	3.70E+01	0.00E+00	8.31E+01
ICP.a.Ag	<4.69E-01	N/A	N/A
ICP.f.Ag	<7.04E+00	N/A	N/A
ICP.w.Ag	<5.52E-01	N/A	N/A
ICP.a.Na	2.42E+04	1.86E+04	2.97E+04
ICP.f.Na	2.54E+04	1.69E+04	3.39E+04
ICP.w.Na	2.04E+04	1.17E+04	2.90E+04
ICP.a.Sr	7.59E+01	0.00E+00	1.90E+02
ICP.f.Sr	1.09E+02	0.00E+00	3.47E+02
ICP.w.Sr	2.41E-01	3.36E-02	4.48E-01
Sulfate	2.23E+03	1.22E+03	3.23E+03
ICP.a.Te	1.66E+01	0.00E+00	4.02E+01
ICP.f.Te	<8.58E+01	N/A	N/A
ICP.w.Te	<6.75E+00	N/A	N/A
ICP.a.Tl	<3.30E+01	N/A	N/A
ICP.f.Tl	<4.96E+02	N/A	N/A

Table B3-7. Analytical-Based Inventory for Composite Sample Data for Tank 241-C-109. (6 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
ICP.w.Tl	<3.90E+01	N/A	N/A
ICP.a.Th	1.31E+01	0.00E+00	2.89E+01
ICP.f.Th	<6.63E+01	N/A	N/A
ICP.w.Th	<5.21E+00	N/A	N/A
ICP.a.Ti	7.27E+00	0.00E+00	2.87E+01
ICP.f.Ti	3.18E+01	0.00E+00	1.50E+02
ICP.w.Ti	<3.82E-01	N/A	N/A
TC(Persulfate)	2.40E+03	1.99E+03	2.81E+03
TC (TIC/TOC/TC)	2.26E+03	1.54E+03	2.98E+03
TIC (Persulfate)	1.58E+03	1.34E+03	1.81E+03
TIC (TIC/TOC/TC)	1.52E+03	9.96E+02	2.04E+03
TOC (Persulfate)	8.24E+02	5.65E+02	1.08E+03
TOC (TIC/TOC/TC)	7.43E+02	4.26E+02	1.06E+03
ICP.a.U	3.09E+03	0.00E+00	6.24E+03
ICP.f.U	3.73E+03	0.00E+00	1.13E+04
ICP.w.U	<3.92E+01	N/A	N/A
Uranium	4.53E+00	0.00E+00	1.21E+01
ICP.a.V	2.46E+00	0.00E+00	5.92E+00
ICP.f.V	<8.12E+00	N/A	N/A
ICP.w.V	<6.29E-01	N/A	N/A
ICP.a.Zn	7.03E+01	3.96E+01	1.01E+02
ICP.f.Zn	1.04E+02	8.74E+01	1.21E+02
ICP.w.Zn	2.36E+00	1.61E+00	3.11E+00
ICP.a.Zr	1.37E+00	0.00E+00	3.08E+00
ICP.f.Zr	<6.86E+00	N/A	N/A
ICP.w.Zr	<5.39E-01	N/A	N/A

Table B3-8. Analytical-Based Inventory for Subsegment Sample Data for Tank 241-C-109. (3 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
Mass Loss - total	1.14E+05	6.42E+04	1.63E+05
Mass Loss - transition 1	7.19E+04	0.00E+00	1.66E+05
Wt%.solids	1.81E+05	9.40E+04	2.68E+05
Am-241.f.GEA	< 1.42E+02	NA	NA
Cs-137.a.GEA	6.24E+03	0.00E+00	4.22E+04
Cs-137.f.GEA	2.12E+05	0.00E+00	4.85E+05
Co-60.f.GEA	<4.80E+00	NA	NA
Eu-154.f.GEA	<7.85E+01	NA	NA
Eu-155.f.GEA	<2.53E+02	NA	NA
Alpha.a	1.53E+01	0.00E+00	3.35E+01
Sr-90.f.Beta	3.00E+05	0.00E+00	1.01E+06
ICP.a.Al	7.57E+03	0.00E+00	7.17E+04
ICP.f.Al	2.21E+04	0.00E+00	6.14E+04
ICP.a.Sb	1.12E+01	2.51E+00	2.00E+01
ICP.f.Sb	<3.42E+01	NA	NA
ICP.a.As	<5.80E+00	NA	NA
ICP.f.As	<7.29E+01	NA	NA
ICP.a.Ba	1.15E+01	0.00E+00	3.76E+01
ICP.f.Ba	1.88E+01	9.55E+00	2.80E+01
ICP.a.Be	< 1.83E-01	NA	NA
ICP.f.Be	<2.30E+00	NA	NA
ICP.a.B	2.08E+01	0.00E+00	6.95E+01
ICP.f.B	<4.29E+01	NA	NA
ICP.a.Cd	1.95E+00	1.15E-01	3.79E+00
ICP.f.Cd	<5.39E+00	NA	NA
ICP.a.Ca	4.77E+03	1.46E+03	8.07E+03
ICP.f.Ca	5.35E+03	1.66E+03	9.03E+03
ICP.a.Ce	<5.83E+00	NA	NA
ICP.f.Ce	<7.33E+01	NA	NA

Table B3-8. Analytical-Based Inventory for Subsegment Sample Data for Tank 241-C-109. (3 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
Chloride	2.24E+02	1.06E+02	3.41E+02
ICP.a.Cr	6.00E+01	1.73E+01	1.03E+02
ICP.f.Cr	7.47E+01	2.76E+01	1.22E+02
ICP.a.Co	<1.07E+01	NA	NA
ICP.f.Co	<1.34E+02	NA	NA
ICP.a.Cu	4.08E+00	1.79E+00	6.38E+00
ICP.f.Cu	3.71E+01	1.54E+01	5.87E+01
Cyanide	1.91E-01	0.00E+00	3.95E-01
Cyanide (IC:W)	2.65E+02	0.00E+00	5.80E+02
ICP.a.Dy	<3.03E-01	NA	NA
ICP.f.Dy	<3.81E+00	NA	NA
Fluoride	1.34E+02	1.73E+01	2.51E+02
ICP.a.Fe	4.07E+03	0.00E+00	1.85E+04
ICP.f.Fe	6.36E+03	0.00E+00	1.48E+04
ICP.a.La	2.28E+00	0.00E+00	5.49E+00
ICP.f.La	<1.39E+01	NA	NA
ICP.a.Pb	1.75E+02	4.88E+01	3.00E+02
ICP.f.Pb	9.09E+02	0.00E+00	3.70E+03
ICP.a.Li	1.41E+00	0.00E+00	4.62E+00
ICP.f.Li	<5.32E+00	NA	NA
ICP.a.Mg	1.49E+02	0.00E+00	4.25E+02
ICP.f.Mg	1.50E+02	2.08E+01	2.79E+02
ICP.a.Mn	1.90E+01	0.00E+00	6.54E+01
ICP.f.Mn	7.24E+01	2.12E+01	1.24E+02
ICP.a.Mo	9.32E+00	2.89E+00	1.57E+01
ICP.f.Mo	1.22E+01	9.02E+00	1.53E+01
ICP.a.Nd	9.72E+00	5.34E-02	1.94E+01
ICP.f.Nd	<3.60E+01	NA	NA
ICP.a.Ni	4.51E+03	0.00E+00	1.11E+04
Nitrate	1.20E+04	4.15E+03	1.99E+04

Table B3-8. Analytical-Based Inventory for Subsegment Sample Data for Tank 241-C-109. (3 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
Nitrite	1.17E+04	6.23E+03	1.73E+04
Phosphate	5.53E+03	0.00E+00	1.19E+04
ICP.a.P	6.85E+03	0.00E+00	1.48E+04
ICP.f.P	4.71E+03	8.53E+02	8.57E+03
ICP.a.K	1.55E+02	0.00E+00	4.21E+02
ICP.a.Re	1.88E+00	0.00E+00	5.55E+00
ICP.f.Re	< 1.24E+01	NA	NA
ICP.a.Rh	< 4.69E+00	NA	NA
ICP.f.Rh	< 5.91E+01	NA	NA
ICP.a.Ru	< 2.00E+00	NA	NA
ICP.f.Ru	< 2.52E+01	NA	NA
ICP.f.Se	< 1.09E+02	NA	NA
ICP.a.Si	2.51E+02	0.00E+00	8.86E+02
ICP.f.Si	1.96E+03	0.00E+00	7.66E+03
ICP.a.Ag	< 4.46E-01	NA	NA
ICP.f.Ag	< 5.61E+00	NA	NA
ICP.a.Na	2.94E+04	0.00E+00	6.22E+04
ICP.f.Na	2.33E+04	7.75E+03	3.89E+04
ICP.a.Sr	1.15E+02	0.00E+00	3.02E+02
ICP.f.Sr	8.53E+01	0.00E+00	2.26E+02
Sulfate	2.29E+03	7.64E+02	3.81E+03
ICP.a.Te	8.67E+00	0.00E+00	4.91E+01
ICP.f.Te	< 6.83E+01	NA	NA
ICP.a.Tl	< 3.14E+01	NA	NA
ICP.f.Tl	< 3.95E+02	NA	NA
ICP.a.Th	< 4.20E+00	NA	NA
ICP.f.Th	< 5.28E+01	NA	NA
ICP.a.Ti	1.45E+00	0.00E+00	7.87E+00
ICP.f.Ti	2.98E+01	0.00E+00	1.16E+02
TC (Persulfate)	2.56E+03	1.09E+03	4.04E+03

Table B3-8. Analytical-Based Inventory for Subsegment Sample Data for Tank 241-C-109. (3 sheets)

Analyte	Inventory (kg or Ci)	LL	UL
TIC (Persulfate)	1.80E+03	9.00E+02	2.70E+03
TOC (Persulfate)	7.45E+02	2.10E+02	1.28E+03
ICP.a.U	3.90E+03	0.00E+00	1.20E+04
ICP.f.U	2.88E+03	0.00E+00	6.04E+03
ICP.a.V	8.67E-01	0.00E+00	3.62E+00
ICP.f.V	<6.47E+00	NA	NA
ICP.a.Zn	5.87E+01	3.05E+01	8.70E+01
ICP.f.Zn	1.02E+02	4.10E+01	1.63E+02
ICP.a.Zr	3.29E+00	0.00E+00	8.75E+00
ICP.f.Zr	<5.92E+00	NA	NA

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

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APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

Statistical analyses required for the safety screening DQO for tank 241-C-109 are reported in this appendix. Although the 1992 sampling of tank 241-C-109 predated current DQO requirements, the current safety screening requirements were applied to the 1992 data set.

C1.0 STATISTICS FOR SAFETY SCREENING DATA QUALITY OBJECTIVES

The safety screening DQO (Dukelow et al. 1995) defines acceptable decision confidence limits in terms of one-sided 95 percent confidence intervals. In this appendix, one-sided confidence limits supporting the safety screening DQO are calculated for tank 241-C-109. All data in this section are from the final laboratory data package for the 1993 core sampling event for tank 241-C-109 (Bell 1993).

Confidence intervals were computed for each sample number from tank 241-C-109 analytical data. The sample numbers and confidence intervals are provided in Table C1-1 for Alpha. Only one DSC exotherm was observed in 241-C-109, therefore no calculation was performed. The upper limit (UL) of a one-sided 95 percent confidence interval on the mean is

$$\hat{\mu} + t_{(df,0.05)} * \hat{\sigma}_{\hat{\mu}}.$$

In this equation, $\hat{\mu}$ is the arithmetic mean of the data, $\hat{\sigma}_{\hat{\mu}}$ is the estimate of the standard deviation of the mean, and $t_{(df,0.05)}$ is the quantile from Student's t distribution with df degrees of freedom for a one-sided 95 percent confidence interval. For the tank 241-C-109 data (per sample number), df equals the number of observations minus one.

The upper limit of the 95 percent confidence interval for each sample number based on alpha data is listed in Table C1-1. Additional data for specific analytes follow in Tables C2-1 to C2-3. Each confidence interval can be used to make the following statement. If the upper limit is less than 41 μCi/g, then one would reject the null hypothesis that the alpha is greater than or equal to 41 μCi/g at the 0.05 level of significance. The data indicate that there is no criticality issue with regard to this tank.

Table C1-1. 95 Percent Confidence Interval Upper Limits for Alpha for Tank 241-C-109 (Units are μCi/g).

Lab Sample ID	Sample Description	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	UL
93-01358-H1	Core 47, Core Composite Homogenized Fusion	9.92E-01	6.80E-02	1.42E+00
93-01363-H1	Core 48, Core Composite Homogenized Fusion	6.46E-02	6.65E-03	1.07E-01
93-01371-H1	Core 49, Core Composite Homogenized Fusion	1.29E-01	6.50E-03	1.70E-01
93-01361-A1T	Core 48, Segment 1, Subsegment D Homogenized Top Acid	5.59E-02	5.90E-03	9.32E-02
92-01361-A1B	Core 48, Segment 1, Subsegment D Homogenized Bottom Acid	6.00E-02	7.40E-03	1.07E-01
93-01367-A1T	Core 49, Segment 1, Subsegment D Homogenized Top Acid	4.76E-02	1.18E-02	1.22E-01
93-01367-A1B	Core 49, Segment 1, Subsegment D Homogenized Bottom Acid	4.85E-02	3.85E-03	7.28E-02
93-01354-N1[1]	Drainable Liquid Tank Composite Acid	5.00E-05	0.00E+00	5.00E-05

Note:
[1]The sample and duplicate are both below the detection limit.

Table C2-1. Core Composite Transuranics (Fusion Preparation).

Core No.	^{237}Np	^{238}Pu[1]	^{239}Pu[1]	^{241}Am$_{GEA}$	^{241}Am$_{AEA}$	Total α
	μCi/g	μCi/g	μCi/g	μCi/g	μCi/g	μCi/g
Core 47	3.65E-04	4.40E-05	0.82	< 0.58	0.32	0.992
Core 48	3.34E-04	7.15E-06	0.063	< 0.71	0.01	0.065
Core 49	3.01E-04	1.11E-05	0.075	< 0.35	0.13	0.129

Note:
[1]Determined from Total Alpha and Isotopic Measurements

Table C2-2. Core Composite Uranium.

Core No.	U_{ICP} Fusion (μg/g)	U_{FL} (μg/g)	^{238}U Mass Fraction	^{235}U Mass Fraction
Liquid composite[1]	< DL	3.7	No measurement	No measurement
Core 47	9,200	12,000	0.993263	0.006573
Core 48	24,700	27,600	0.993038	0.006852
Core 49	4,700	7,500	0.993109	0.006753

Notes:

FL = laser fluorimetry
DL = detection limit

[1]There was no plutonium measurement on the liquid composite because the concentration was too low.

Table C2-3. Plutonium Concentration and Isotopic Distribution.

Core No.	Total Pu α (μCi/g)	^{238}Pu Mass Fraction	^{239}Pu Mass Fraction	^{240}Pu Mass Fraction	^{241}Pu Mass Fraction	^{242}Pu Mass Fraction
Core 47	0.88	5E-05	0.932237	0.066256	0.001216	2.41E-04
Core 48	0.065	1.1E-04	0.976356	0.022995	3.64E-04	1.76E-04
Core 49	0.079	1.4E-04	0.949629	0.048786	0.001119	3.29E-04

C2.0 APPENDIX C REFERENCES

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-C-109

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-C-109

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available chemical information for tank 241-C-109 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

D1.0 IDENTIFY/COMPILE INVENTORY SOURCES

The following sources were considered in the derivation of a best-basis inventory for the tank.

- Sample data from 1992 push mode core samples - cores 47, 48, and 49 (Bell 1993)
- The Hanford Defined Waste (HDW) model document (Agnew et al. 1997) provides tank content estimates, derived from process history and transfer information, in terms of component concentrations and inventories.
- Process data from 1951 (Schneider 1951) and 1958 (GE 1958)

D2.0 COMPARE COMPONENT INVENTORY VALUES AND NOTE SIGNIFICANT DIFFERENCES

HDW model inventories and sampling based inventories are compared in Tables D-1 and D-2. The tank volume used to generate the HDW inventory was 235 kL (62 kgal) of sludge. This differs slightly from the Hanlon (1996) estimate of 250 kL (66 kgal) of waste, consisting of 235 kL (62 kgal) sludge and 15 kL (4 kgal) supernatant. The HDW model density for the sludge waste was assumed to be 1.34 g/mL. The sampling based solids inventory, using the core composite data are based on 235 kL of solids with a bulk density of 1.23 g/ml. This results in an RPD of 8.6 percent for analytes with roughly the same concentration.

Table D-1. Sampling-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-C-109.

Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)	Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)
Al	24,300	611	Ni	4,060	6,810
Ba	19.7	NR	NO_2^-	11,800	19,200
Bi	NR	493	NO_3^-	11,700	2,570
Ca	5,510	5,540	Pb	971	832
Cl^-	212	372	P as PO_4^{-3}	16,100	6,030
Cr	72.2	18.6	Si	1,950	238
Cu	18.2	NR	S as SO_4^{-2}	2,230	566
F^- [3]	202	99.9	Sr	109	0
Fe	5,410	12,500	TOC	824	492
$Fe(CN)_6^{-4}$	NR	16,500	U_{total}	3,730	1,890
K	157	156	Zn	104	NR
La	12.7	0	Zr	NR	0.825
Mn	37	0	H_2O (Wt%)	35.7	62.2
Na	25,400	19,100	density (kg/L)	1.23	1.34

Notes:

NR = not reported

[1]See Appendix B (Table B3-7)
[2]Agnew et al. (1997)
[3]Fluoride based on water soluble portion only.

Table D-2. Sampling and Predicted Inventory Estimates for Radioactive Components in Tank 241-C-109.

Analyte	Sampling[1] Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)	Analyte	Sampling[1] Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)
^{14}C	0.00569	0.177	^{154}Eu	<65.4	1.76
^{90}Sr	221,000	349,000	^{155}Eu	<24.4	167
^{99}Tc	30.6	0.814	^{237}Np	0.0963	0.00485
^{129}I	NR	0.00154	$^{239/240}Pu$	92.3	101
^{137}Cs	237,000	151,000	^{241}Am	44.6	33.7

Notes:

[1] See Appendix B (Table B3-7)
[2]Agnew et al. (1997).

D3.0 REVIEW AND EVALUATION OF COMPONENT INVENTORIES

D3.1 WASTE HISTORY FOR TANK 241-C-109

A brief synopsis of the most relevant facts regarding the operating history of this tank is provided. Section 2.3 provides a more detailed description of the waste history for tank 241-C-109.

D3.1.1 Process History for Tank 241-C-109

Tank 241-C-109 began its service life in 1948, when it received bismuth phosphate first-cycle decontamination (1C) waste as the last tank in the 241-C-107, -108, and -109 cascade. The tank was emptied, except for a 37,900 L (10,000 gal) heel in 1952, and was then used as a temporary supernatant storage tank for 241-C Tank Farm waste removal operations. Tank 241- C-109 was emptied again in early 1953 and was soon after filled through the cascade with unscavenged uranium recovery waste.

From 1955 to 1958, tank 241-C-109 was used as a primary settling tank for "In-Tank" ferrocyanide scavenging. This involved the repeated transfer of scavenged waste into the tank to allow ^{137}Cs and ^{90}Sr bearing particulate material to settle; the resulting decontaminated supernatant was then transferred out of the tank to cribs. This is, therefore, the period when tank 241-C-109 accumulated most of its solids contents. After ferrocyanide scavenging was completed, tank 241-C-109 received coating cladding waste supernatant, which was later pumped out of the tank.

Cladding waste supernatant transferred to tank 241-C-109 from tank 241-C-105 in 1959 likely contained very little solids content. Although cladding waste tends to be relatively high in solids, these solids likely had already settled in tank 241-C-105 and were probably not included in the supernatant transferred to tank 241-C-109.

D3.1.2 Major Analytes of Waste Types Transferred into Tank 241-C-109

First-cycle decontamination (1C) waste entered tank 241-C-109 through cascade lines in 1948. This waste was produced by the bismuth phosphate process at B-Plant. Analytes characteristic of 1C waste expected to be present in concentrations around 10,000 μg/g include iron, bismuth, and phosphate (Schneider 1951; Agnew et al. 1997). The 1C waste, if present, is expected to be located in the dished region at the bottom of the tank. Transfer records indicate that the sludge was discharged there before the additions of unscavanged UR waste to the tank started (Agnew et al. 1996).

The scavenged waste was settled and the supernatant was sampled and then decanted to a crib resulting in the accumulation of solids in tank 241-C-109. These solids have a much greater activity than the 1C waste from the scavenged ^{137}Cs and ^{90}Sr present. Other compositional changes include much higher levels of calcium, non-radioactive strontium, and nickel than in 1C waste (Schneider 1951; Agnew et al. 1997). These solids make up the majority of the tank solids volume and are located on top of the 1C sludge waste.

Produced during the dissolution of aluminum fuel cladding at PUREX, cladding waste (CWP1) will have a much different composition than the 1C waste or the ferrocyanide scavenging waste. Cladding waste has comparatively high (greater than 100,000 μg/g) aluminum concentrations, and is low in bismuth, phosphate, and other analytes characteristic of 1C and scavenging wastes (Schneider 1951; Agnew et al. 1997). The HDW model assumes that the CWP1 waste did not contribute to the solids formation in the tank. However, Hill et al. (1995) predicts CWP1 to be the tertiary waste type in the tank. Because of the uncertainty regarding the flow properties of the waste in tank to tank transfers, the contribution of CWP1 to the tank is not well defined.

Hot Semiworks (HS) waste was the effluent from strontium recovery operations. It contained elevated concentrations of lead (estimated at greater than 20,000 μg/g) and ^{90}Sr (estimated at greater than 10,000 μCi/g) that distinguished it from the other wastes present. It lacked bismuth, aluminum, nickel, and calcium. Very little HS waste was generated. The HS waste is assumed to be the top layer of waste as reported in Agnew et al. (1997).

D3.2 CONTRIBUTING WASTE TYPES

There are two interpretations of the waste types that contribute to the waste inventory in tank 241-C-109. They agree on the main waste contributors, but differ on the smaller ones. The HDW model (Agnew et al. 1997) predicts that the tank contains a total of 235 kL of solid waste made up of three waste types.

- 38 kL (10 kgal) first cycle decontamination waste from the early $BiPO_4$ process (1C).
- 170 kL (45 kgal) of ferrocyanide sludge produced by in-tank or in-farm scavenging (TFeCN)
- 27 kL (7 kgal) of hot semiworks from strontium recovery operations (HS).

The Sort on Radioactive Waste Type model (Hill 1995) lists four waste types contributing to tank 241-C-109 solids. However, no quantification of their contribution is made.

- Scavenged UR/TBP uranium-extraction waste at U Plant (TBP-F) as the primary waste type.
- First decontamination cycle waste (1C) from the $BiPO_4$ process at B Plant as a secondary waste type.

- PUREX Plant aluminum fuel cladding waste (CW) as a tertiary waste type
- Ion exchange (IX) from the cesium recovery process at B Plant as another contributing waste type.

D3.3 EVALUATION OF TANK WASTE VOLUME

The tank has a capacity of 2,010 kL (530 kgal). Currently, Hanlon (1996) estimates a volume of 250 kL (66 kgal) of waste, consisting of 235 kL (62 kgal) of sludge and 15 kL (4 kgal) of supernatant. No description of sludge types or source is given. The analytical and surveillance data suggest that the sludge is heterogeneous, with significantly different chemical compositions depending on waste depth. Manual tape surveillance readings report a waste level at 47.63 cm (18.75 in), which corresponds to 242 kL (64 kgal) of total waste, confirming the Hanlon (1996) estimate.

D3.4 CONTRIBUTING WASTE TYPES

D3.4.1 Sludge Contribution to the Best Basis Inventory

Tank 241-C-109 waste is approximately 94 percent sludge with the remaining waste classified as supernatant. For this evaluation, the following assumptions and observations are made. Because of the lack of independent analytical and historical data, the best-basis inventory calculation are based on a sludge volume of 235 kL, a density or 1.23 g/mL, derived from extrusion data, and analyte concentration means derived from the core composite data (Appendix B, Table B3-6).

D3.4.2 Supernatant Contribution to the Best Basis Inventory

The contribution of the supernatant is assumed to be negligible at this time. Neutron and gamma scans indicate approximately 15 kL of supernatant on top of the sludge layer. However, because of the small volume of the liquid, and limited sample data for the supernatant, the overall effect on the tank inventory is assumed to be within the uncertainties in the sludge inventory calculations.

D3.5 ESTIMATED COMPONENT INVENTORIES

Discrepancies between the HDW model inventories and the data-derived inventories are noted, and possible reasons for them are explained in the following narrative.

D3.5.1 Aluminum. The HDW model underpredicts the amount of Al in tank 241-C-109 by more than 30 times that reported by the sample data. The HDW model indicates three waste types contributing to the sludge in tank 241-C-109 and disregards PUREX cladding waste (CWP1) added from tank 241-C-105 as a potential solids contributor to the waste on top of the TFeCN waste. CWP1 is extremely high aluminum concentrations, and sample data indicates an increase in Al at the top of the waste. The aluminum concentration in the tank is highly variable (RSD of the mean = 45 percent).

Additionally, although this CWP1 may have been principally a supernatant transfer, there may have been significant soluble aluminum that was transferred which precipitated from the change in pH. However, aluminum is seen in large concentrations as a function of depth through the tank sample data where the HDW model predicts waste types that have much smaller concentrations or no Al present, suggesting a deficient source term and an incomplete description of the solubility behavior for this analyte. The assigned waste type (TFeCN) may have Al in the sludge that came from scavenged evaporator bottoms (for example, 1C and CWP1) waste that the HDW model includes, but incompletely describes, in the analysis.

D3.5.2 Calcium. The HDW model appears to quantify the calcium inventory satisfactorily, agreeing to within 1 percent of the sample-based estimate. Calcium was widely used in the ferrocyanide scavenging process, and substantial documentation exists to quantify its use and distribution (GE 1958). A modest increase in concentration as a function of depth is noted on inspection of the data.

D3.5.3 Iron. Iron is seen in all the waste types added to tank 241-C-109 and from sample data appears to be distributed evenly through the tank, both vertically within a core and between different cores. Iron was a principal component in the ferrocyanide scavenging and bismuth phosphate processes. The reason behind the difference between the iron inventory derived from sample data and HDW model estimate for iron, with the HDW model-based inventory having twice the sample-based inventory, is not clear at this time. However, the observed sample concentrations are highly variable, with sample data values ranging from 5,900 mg/g to 35,200 mg/g, with a relative standard deviation of the mean of 34 percent. This variability, coupled with the difference in densities used in the estimates may be responsible for most of the difference observed.

D3.5.4 Ferrocyanide. No ferrocyanide appears to remain after 40 years of storage. Abundant evidence is available to support that it was present in the past (elevated nickel and calcium concentrations, high ^{137}Cs activity, and extensive process documentation). However, almost no cyanide is detectable and no exotherms are observed, strongly suggesting the ferrocyanide has degraded away, supporting the waste aging hypothesis, as indicated by Lilga et al. (1992, 1993, 1994, 1995, and 1996).

D3.5.5 Lead. The process history suggests a small amount of lead present in a relatively high concentration. The evidence from the sample data supports this description. The sample data and HDW model estimates agree well (RPD = 15.4 percent). Inspection of the sample data shows lead irregularly distributed both as a function of depth as well as from one side of the tank to the other. A small amount of waste highly concentrated in lead (such as the HS waste indicated in the process history), together with modest tank transfer activity, may account for the observed behavior.

D3.5.6 Lanthanum and manganese. Sample data show traces of La and Mn, suggesting impurities in the process chemicals, or mixing with waste types that contained these materials. They are not indicated as principal process chemical in any of the waste types added to tank 241-C-109.

D3.5.7 Sodium. The HDW model and sample data estimates are in reasonable agreement (RPD = 28 percent).

D3.5.8 Nickel. The HDW model and sample data estimates both indicate elevated concentrations and inventories of nickel. However, there is moderate disagreement regarding the magnitude of the nickel inventory (RPD = 51 percent). The nickel precipitates in the waste are very insoluble, and may not be fully quantitated by the acid digestion preparation. However, for this analyte, the fusion results are suspect because of possible cross-contamination from the fusion preparation (nickel crucible use). Therefore, the acid digestion results were used to estimate the inventory, and may understate the nickel concentration.

D3.5.9 Nitrate, nitrite and phosphate (phosphorous). Substantial differences are observed between the HDW model and sampling data estimates. These differences may be attributable to source term discrepancies and assumptions regarding the distribution of all three anions, and assumptions regarding the possible decomposition of nitrate in the HDW model. The sample data for these analytes are not highly variable (RSD of the mean for nitrate = 9.5 percent; nitrite = 5.1 percent; phosphorous = 10 percent).

D3.5.10 Sulfate. The sample data derived inventory for sulfate is four times the HDW model predicted inventory. In the HDW model, sulfate is found in modest concentrations in the majority of the waste types added to tank 241-C-109. It was a process chemical used in the ferrocyanide scavenging campaign. The reason for the difference is likely the solubility assumptions made regarding sulfate in the HDW model. The HDW model assumes that no sulfate precipitates with the waste solids (that is, it remains in the interstitial liquids). The sample data ranges from 6,200 mg/g to 9,600 mg/g with a relative standard deviation of the mean of about 10 percent, thus its distribution behavior does not seem to be contributing to the discrepancy.

D3.5.11 Silicon. Silicon is not indicated as a principal process chemical in any of the wastes proposed as depositing solids, except for CWP1. The concentration and distribution behavior of silicon matches well with the elevated aluminum concentrations observed. The concentration of silicon is highly variable (RSD of the mean = 66.7 percent), and dependent on the sample preparation method (only the fusion preparation appears to fully quantitate silicon). These corresponding behaviors suggest that these analytes (Al and Si) were deposited together.

D3.5.12 Strontium and Strontium-90. Sample data show traces of Sr in the waste, suggesting impurities in the process chemicals or slight mixing with wastes that contained it. It was not indicated as a principal process chemical in the wastes added to tank 241-C-109. However, strontium was added to the In-Plant scavenged waste and evidence of this has been observed in several tanks.

Elevated ^{90}Sr levels were observed in the wastes, with extremely high (2,200 - 4,600 $\mu Ci/g$) values found on the tops of cores 47 and 49, with concentrations decreasing as a function of depth, but remaining high (approximately 150 $\mu Ci/g$). This was expected from the process history associated with this tank. Hot Semiworks waste was believed to have very high concentrations of ^{90}Sr. Furthermore, in addition to ^{137}Cs scavenging with ferrocyanide, ^{90}Sr was scavenged using $Ca_3(PO_4)_2$ and $Sr_3(PO_4)_2$, suggesting that the Sr and ^{90}Sr concentrations in these wastes would be higher than those observed for bismuth phosphate, cladding waste, or uranium recovery waste.

D3.5.13 Uranium. Uranium values from sample data results indicate a U inventory two times the amount reported in the HDW model. The higher U concentrations in subsegment B compared to subsegment C indicates uranium settling on top of the TFeCN waste. CWP1 waste added to the scavenged waste from tank 241-C-105 could contain substantial concentrations of uranium from dissolution of the fuel core material during decladding.

D3.5.14 Cesium-137. The HDW model and sample data estimates both indicate elevated concentration and inventories of ^{137}Cs. However, there is moderate disagreement regarding the magnitude of the radiocesium inventory (RPD = 44.3 percent). Factors affecting this comparison include source term differences between the estimates and assumptions regarding cesium mobility.

D4.0 BEST-BASIS INVENTORY ESTIMATE

As part of this effort, an evaluation of available chemical information for tank 241-C-109 was performed, including the following:

- The inventory estimate generated by the HDW model (Agnew et al. 1997).
- Evaluation of 1992 inventory data from a push mode core sample.

- Interpretation of waste transfer records to reconcile contradictory transaction data between Agnew et al. (1996) and Hill et al. (1995).

Based on this evaluation a best-basis inventory was developed for tank 241-C-109. The sampling data was chosen as the best basis for those analytes, for the following reasons:

- The sample data supports expected findings from historical waste transfer records.

- The HDW model assumes no addition to the solids from the transfer of secondary CW from tank 241-C-105.

- Waste transaction records and tank sampling data provide strong evidence that aluminum cladding solids are present.

- For those few analytes where no values were available from the sampling-based inventory, the HDW model values were used.

The best-basis inventory estimate for tank 241-C-109 is presented in Tables D-3 and D-4.

Table D-3. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-109. (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	24,300	S	
Bi	493	M	
Ca	5,510	S	
Cl^-	212	S	
TIC as CO_3^{-2}	1,580	S	
Cr	72.2	S	
F^-	202	S	
Fe	5,410	S	
Hg	0.802	M	NR in sample data.
K	157	S	
La	12.7	S	
Mn	37	S	
Na	25,400	S	
Ni	4,060	S	

Table D-3. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-109. (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
NO_2^-	11,800	S	
NO_3^-	11,700	S	
OH^-	58,050	E	From charge balance
Pb	971	S	
P as PO_4^{-3}	16,100	S	From ICP measurement
Si	1,950	S	
SO_4^{-2}	2,230	S	
Sr	109	S	
TOC	824	S	
U_{TOTAL}	3,730	S	
Zr	0.825	M	Less than value in sample.

Note:

[1]S = Sample-based, M = HDW model-based, and E = Engineering assessment-based

Table D-4. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-C-109. (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	NR		
^{14}C	0.00569	S	
^{59}Ni	NR		
^{60}Co	NR		
^{63}Ni	NR		
^{79}Se	NR		
^{90}Sr	221,000	S	
^{90}Y	221,000	S	Based on ^{90}Sr
^{93}Zr	NR		
^{93m}Nb	NR		
^{99}Tc	NR		
^{106}Ru	NR		
^{113m}Cd	NR		
^{125}Sb	NR		
^{126}Sn	NR		
^{129}I	NR		
^{134}Cs	NR		
^{137}Cs	237,000	S	
^{137m}Ba	224,000	S	Based on ^{137}Cs
^{151}Sm	NR		
^{152}Eu	NR		
^{154}Eu	NR		
^{155}Eu	NR		
^{226}Ra	NR		
^{227}Ac	NR		
^{228}Ra	NR		
^{229}Th	NR		
^{231}Pa	NR		
^{232}Th	NR		

Table D-4. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-C-109. (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{232}U	NR		
^{233}U	NR		
^{234}U	NR		
^{235}U	NR		
^{236}U	NR		
^{237}Np	NR		
^{238}Pu	NR		
^{238}U	NR		
$^{239/240}Pu$	98.6	S	
^{240}Pu	NR		
^{241}Am	44.5	S	
^{241}Pu	NR		
^{242}Cm	NR		
^{242}Pu	NR		
^{243}Am	NR		
^{243}Cm	NR		
^{244}Cm	NR		

Note:

[1]S = Sample-based, M = HDW model-based, and E = Engineering assessment-based

D5.0 APPENDIX D REFERENCES

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-C-109

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APPENDIX E

BIBLIOGRAPHY FOR TANK 241-C-109

Appendix E provides a bibliography of information that supports the characterization of tank 241-C-109. This bibliography represents an in-depth literature search of all known information sources that provide sampling, analysis, surveillance, and modeling information, as well as processing occurrences associated with tank 241-C-109 and its respective waste types.

The references in this bibliography are separated into three broad categories containing references broken down into subgroups. These categories and their subgroups are listed below.

I. NON-ANALYTICAL DATA

- Ia. Models/Waste Type Inventories/Campaign Information
- Ib. Fill History/Waste Transfer Records
- Ic. Surveillance/Tank Configuration
- Id. Sample Planning/Tank Prioritization
- Ie. Data Quality Objectives/Customers of Characterization Data

II. ANALYTICAL DATA

- IIa. Sampling of Tank Waste and Waste Types
- IIb. Sampling of 1C Waste Stream

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

- IIIa. Inventories using both Campaign and Analytical Information
- IIIb. Compendium of Existing Physical and Chemical Documented Data Sources
- IIIc. Other - Non-documented or Electronic Sources

IV. OTHER RESOURCES

This bibliography is broken down into the appropriate sections of material to use, with an annotation at the end of each reference describing the information source. Where possible, a reference is provided for information sources. A majority of the information listed below may be found in the Lockheed Martin Hanford Corporation Tank Characterization and Safety Resource Center.

I. NON-ANALYTICAL DATA

Ia. Models/Waste Type Inventories/Campaign Information

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, LA-UR-96-3860, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains waste type summaries, primary chemical compound/analyte and radionuclide estimates for sludge, supernatant, and solids, as well as SMM, TLM, and individual tank inventory estimates.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

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McKinley, S. G., June 1993, *Pacific Northwest Laboratory Tank Waste Characterization Project Technical Project Plan*, Pacific Northwest Laboratory, Richland, Washington.

- Documentation for laboratory work in support of Bell (1993).

Postma, A. K., G. S. Barney, G. L. Borsheim, R. J., Cash, M. D. Crippen, D. R. Dickinson, J. M. Grigsby, D. W. Jeppson, C. S. Simmons, and B. C. Simpson, 1994, *Ferrocyanide Safety Program: Safety Criteria for Ferrocyanide Watchlist Tanks*, WHC-EP-0691, Westinghouse Hanford Company, Richland, Washington.

- Document which was developed before the safety screening and ferrocyanide DQOs specifying safety criteria.

Smith, H. E., 1992, *Technical Project Plan - Response to WHC-SOW-91-0006 for the 222-S Analytical Laboratory*, WHC-SD-CP-TP-070, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Documentation for laboratory work in support of Winters et al. (1991).

Winters, W. I., 1992, *Technical Project Plan for 222-S Laboratory in Support of Tank Waste Remediation System Tank Waste Characterization Plan (WHC-SD-WM-PLN-047, Rev. 0) and Statement of Work (WHC-SOW-93-0002)*, WHC-SD-WM-TPP-047, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Provides the 222-S Laboratory response to the statement of work. It describes how the laboratory plans to analyze the samples and lists exceptions.

Winters, W. I., J. G. Hill, B. C. Simpson, J. W. Buck, P. J. Chamberlain, and V. L. Hunter, 1991, *Waste Characterization Plan for the Hanford Site Single-Shell Tanks*, WHC-EP-0210, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

- This revision added *Appendix I Test Plan for Sampling and Analysis of Ten Single-Shell Tanks* and revised Appendix D (the QA project plan).

Ie. Data Quality Objectives and Customers of Characterization Data

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Contains objectives to sample all tanks for safety concerns (ferrocyanide, organic, flammable gas, and criticality) as well as decision thresholds for energetics, criticality and flammability.

Meacham, J. E., R. J. Cash, B. A. Pulsipher, and G. Chen, 1995, *Data Requirements for the Ferrocyanide Safety Issue Developed Through the Data Quality Objective Process*, WHC-SD-WM-DQO-007, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Contains ferrocyanide program data needs, list of tanks to be evaluated, decision thresholds, and decision logic flow diagram.

Osborne, J. W., J. L. Huckaby, T. P. Rudolph, E. R. Hewitt, D. D. Mahlum, J. Y. Young and C. M. Anderson, 1994, *Data Quality Objectives for Generic In-Tank Health and Safety Issue Resolution*, WHC-SD-WM-DQO-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains program data needs, list of tanks to be evaluated, decision thresholds, and decision logic flow diagram.

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

IIa. Sampling of Tank 241-C-109

Bell, M. L., 1993, *Single-Shell Tank Characterization Project and Safety Analysis Project Core 47, 48, and 49, Validation Report Tank 241-C-109*, WHC-SD-WM-DP-036, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains sample analyses and data validation from 1992 tank 241-C-109 core sampling event.

Caprio, G. S., 1995, *Vapor and Gas Sampling of Single-Shell Tank 241-C-109 Using the Vapor Sampling System*, WHC-SD-WM-RPT-111, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Clauss, J. W., A. K. Sharma, M. W. Ligotke, M. McCulloch, K. H. Pool, J. S. Fruchter, R. B. Lucke, S. C. Goheen, and B. D. McVeety, 1995, *Vapor Space Characterization of Waste Tank 241-C-109 (In Situ): Results from Samples Collected on 6/23/94, PNL-10366*, Pacific Northwest National Laboratory, Richland, Washington.

- These documents provide the data and interpretation for various vaporspace sampling events.

Colton, N. G., 1996, *Status Report: Pretreatment Chemistry Evaluation - Wash and Leach Factors for the Single-Shell Tank Waste Inventory*, PNNL-11290, Pacific Northwest National Laboratory, Richland, Washington.

- This contains sludge wash data for all single-shell tanks evaluated since 1986, including tank 241-C-109.

Edrington, R. S., 1990, "BY and C Tank Farm Supernate Sample Analyses," (internal memorandum number 16220-PCL90-117 to R. K. Tranbarger, November 20), Westinghouse Hanford Company, Richland, Washington.

- This document provides data for selected analytes on several supernatant samples from BY and C tank farms.

Fowler, K. D., 1992, "Head Space Sampling of Tank 241-C-109", (internal memorandum number7K210-92-434, to G. T. Dukelow, August 27), Westinghouse Hanford Company, Richland, Washington.

- This contains the data and interpretation for various vapor space sampling events.

Huckaby, J. L. and Bratzel, D. R., 1995, *Tank 241-C-109 Headspace Gas and Vapor Characterization Results for Samples Collected in August 1994*, WHC-SD-WM-ER-424, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Contains specific headspace gas and vapor characterization results for all vapor sampling events to date. In addition, changes have been made to the original vapor reports to qualify the data based on quality assurance issues associated with the performing laboratories.

Pingel, L. A., 1994, *Results from the In-Situ Vapor Sampling of Waste Tank C-109*, (internal memorandum 8E920-SAS94-106 to J. L. Huckaby), Westinghouse Hanford Company, Richland, Washington.

- Contains vapor sampling results for tank 241-C-109.

IIb. Sampling of 1C and Ferrocyanide Waste Stream

This section presents sampling data of other tanks that contain 1C waste.

Bell, M. L., 1993, Single-Shell Tank Characterization Project and Safety Analysis Project Cores 34, 35, and 36, Validation Report Tank 241-C-112, WHC-SD-WM-DP-026, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains sample analyses and data validation from 1992 tank 241-C-112 core sampling event.

Conner, J. M., 1996, *Final Report for Tank 241-BX-112, Auger Samples 95-AUG-047 and 95-AUG-048*, WHC-SD-WM-DP-157, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Presents analytical results from the 1995 auger sampling event.

Duchsherer, M. J., 1993, *Single-Shell Tank Waste Characterization 241-T-104, Core 45 and 46 Narrative*, WHC-SD-WM-DP-032, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Presents analytical results from the 1992 core sampling event.

Schreiber, R. D., 1995, *45-Day Safety Screening Results and Final Report for Tank 241-BX-110, Auger Samples 95-AUG-045 and 95-AUG-046*, WHC-SD-WM-DP-155, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Presents analytical results from the 1995 auger sampling event.

Svancara, G. B. and K. N. Pool, 1993, *WHC 222-S and PNL-325 Single-Shell Tank Waste Characterization, 241-T-107 Cores 50, 51, and 52 - Data Package and Validation Summaries*, WHC-SD-WM-DP-042, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Contains sample analyses and data validation from 1992 to 1993 tank 241-T-107 core sampling event.

Valenzuela, B. D. and L. Jensen, 1994, *Tank Characterization Report for Single-Shell Tank 241-T-107*, WHC-SD-WM-ER-382, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document expands on the evaluation of the data of the sample analyses from 1992 to 1993 tank 241-T-107 core sampling event.

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

IIIa. Inventories from Campaign and Analytical Information

Agnew, S. F., 1995, *Letter Report: Strategy for Analytical Data Comparisons to HDW Model*, (letter CST-4:95-sfa272 to Susan Eberlein, September 28), Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains proposed tank groups based on TLM, and statistical method for comparing analytical information to HDW predictions.

Allen, G. K., 1976, *Estimated Inventory of Chemicals Added to Underground Waste Tanks, 1944 - 1975*, ARH-CD-601B, Atlantic Richfield Hanford Company Operations, Richland, Washington.

- Contains major components for waste types, and some assumptions.

Allen, G. K., 1975, *Hanford Liquid Waste Inventory As Of Sept. 30, 1974*, ARH-CD-229, Atlantic Richfield Hanford Company Operations, Richland, Washington.

- Contains major components for waste types, and some assumptions.

Grigsby, J. M., 1992, *Ferrocyanide Waste Tank Hazard Assessment - Interim Report*, WHC-SD-WM-RPT-032, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Contains inventory estimates from physical and campaign data for a few constituents in ferrocyanide containing tanks and a few laboratory analyses.

Schmittroth, F. A., 1995, *Inventories for Low-Level Tank Waste*, WHC-SD-WM-RPT-164, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains a global inventory based on process knowledge and radioactive decay estimations using ORIGEN2. Pu and U waste contributions are taken at 1 percent of the amount used in processes. Also compares information on Tc-99 from both ORIGEN2 and analytical data.

IIIb. Compendium of data from other sources physical and chemical

Agnew, S. F., and J. G. Watkin, 1994, *Estimation of Limiting Solubilities for Ionic Species in Hanford Waste Tank Supernates*, LA-UR-94-3590, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Document gives solubility ranges used for key chemical and radionuclide components based on supernatant sample analyses.

Brevick, C.H., L. A. Gaddis, and E. D. Johnson, 1995, *Tank Waste Source Term Inventory Validation, Volume I & II*, WHC-SD-WM-ER-400, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains a quick reference to sampling information in spreadsheet or graphical form for 23 chemicals and 11 radionuclides for all the tanks.

Hanlon, B. M., 1996, *Tank Farm Surveillance and Waste Status Summary Report for Month Ending October 31, 1996*, WHC-EP-0182-103, Westinghouse Hanford Company, Richland, Washington.

- These documents contain a monthly summary of: fill volumes, watchlist tanks, occurrences, integrity information, equipment readings, equipment status, tank location, and other miscellaneous tank information. Grouped here are all the monthly summaries from December 1947 to the present; however, Hanlon has only authored the monthly summaries from November 1989 to the present.

Husa, E. I., R. E. Raymond, R. K. Welty, S. M. Griffith, B. M. Hanlon, R. R. Rios, and N. J. Vermeulen, 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document contains in-tank photos as well as summaries on the tank description, leak detection system, and tank status.

Husa, E. I., 1995, *Hanford Waste Tank Preliminary Dryness Evaluation*, WHC-SD-WM-TI-703, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Document gives assessment of relative dryness between tanks.

Jungfleisch, F. M., 1980, *Hanford High-Level Defense Waste Characterization - A Status Report*, RHO-CD-1019, Rockwell Hanford Operations, Richland, Washington.

- Document provides status information to plan outlined by G. W. Grimes, October 1977, containing a summary of sampling, characterization, and analysis data for the tanks sampled.

Remund, K. M., G. Chen, S. A. Hartley, J. York, and B. C. Simpson, 1995, *Historical Tank Content Estimate and Sampling Estimate Comparisons*, PNL-10840, Pacific Northwest Laboratory, Richland, Washington.

- Document contains a statistical evaluation of the HDW inventory estimate against analytical values from 12 existing TCRs using a select component data set.

Shelton, L. W., 1996, *Chemical and Radionuclide Inventory for Single and Double Shell Tanks*, (internal memorandum 74A20-96-30 to D. J. Washenfelder, February 28), Westinghouse Hanford Company, Richland, Washington.

- Memorandum contains an tank inventory estimate based on analytical information.

Shelton, L. W., 1995, *Chemical and Radionuclide Inventory for Single and Double Shell Tanks*, (internal memorandum 75520-95-007 to R. M. Orme, August 8), Westinghouse Hanford Company, Richland, Washington.

- Memorandum contains an tank inventory estimate based on analytical information.

Shelton, L. W., 1995, *Radionuclide Inventories for Single and Double Shell Tanks*, (internal memorandum 71320-95-002 to F. M. Cooney, February 14), Westinghouse Hanford Company, Richland, Washington.

- Memorandum contains an tank inventory estimate based on analytical information.

IIIc. Other - Non-documented or Electronic Sources

Pacific Northwest National Laboratory, 1997, TWINS: Tank Waste Information Network System. In: SYBASE version 4. Available: Hanford Local Area Network (HLAN), Lockheed Martin Services, Richland, Washington; or TCP/IP access, Pacific Northwest National Laboratory, Richland, Washington.

- Database provides access to SACS, TMACS, TCD, and Kaiser Electronic data.

Pacific Northwest National Laboratory, 1997, TCD: Tank Characterization Database. In: SYBASE version 4.0. Available: Tank Waste Information Network System (TWINS), Pacific Northwest National Laboratory, Richland, Washington

- Database contains qualified raw sampling data taken in the past few years from 222-S Laboratory. A small amount of information from the 325 Laboratory data is included at this time.

IV. OTHER RESOURCES

Fluor Daniel Northwest, 1997, Fluor Daniel Northwest Tank Characterization Library. In hard copy. Available: Fluor Daniel Northwest, 200E, Trailer MO-971, room 26, Sheryl Consort: custodian, Fluor Daniel Northwest, Richland, Washington.

- A resource of 200 Area tank, process campaign, reactor, and other historical records, unclassified and declassified.

WHC, 1995, 222-S Laboratory RIDS: Records Inventory and Disposition Schedule. In: Hardcopy. Available: In 222-S Laboratory RIDS index, WHC Archives, Westinghouse Hanford Company, Richland, Washington.

- A RIDS report of the information archived for 1992 to 1993 from the 222-S Laboratory, last printed May 17, 1995. Lab notebooks may have been archived that contain pertinent information.

LMHC, 1997, L.S.I.S.: Large Scale Information System, ERS DB - Engineering Release Station Database. In: Database. Available: Hanford Local Area Network (HLAN), Lockheed Martin Hanford Corporation, Richland, Washington.

- Database with any released document information. Most expedient to search by title and keyword for tank in question.

Lockheed Martin Services, 1997, RMIS: Record Management Information System, Records Database. In: Database. Available: HLAN, Lockheed Martin Services, Richland, Washington.

- Records is a database of all released documents since November 1995, which will be back loaded with previous years' data. It can be queried to find documents for any subject either in the keyword or description field.

Lockheed Martin Services, 1997, RMIS: Record Management Information System, TFIC Database. In: Database. Available: HLAN, Lockheed Martin Services, Richland, Washington.

- TFIC is a database of tank related reports, memos, and letters that have been optically scanned. The database can be queried to find indexed information for a tank [in the tank or description field] or information referenced to any subject either in the keyword or description field.

LMHC, 1997, TCRC: Tank Characterization and Safety Resource Center. In: hard copy. Available: 2750E, room A-243, Ann Young: custodian, Lockheed Martin Hanford Corporation, Richland, Washington.

- A resource of TWRS characterization data including: hard copy file folders of sampling data for each tank, an index of multiple tank documents folders, physical/chemical data compendiums, and studies or reports on 200 Area Tanks or Tank Waste generated by various contractors.

WHC, 1996, 209-E Waste Tanks Document Index. In: Hard copy. Available: Fluor Daniel Northwest Library, Fluor Daniel Northwest, Richland, Washington.

- An index of general and tank specific information for the 200 Area tanks.

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